THE

INDIAN FORESTER.

Vol. VIII] JULY 1882. [No. 1.

The Cape Forests.

REPORT OF THE SUPERINTENDENT OF WOODS AND FORESTS, M. LE COMTE VASSELOT DE REGNE.

PART I.—*Description and Condition, from a Forester's point of view, of the country visited.* 1882.

KNYSNA DISTRICT.

Route followed.

IN pursuance of the instructions of the Honourable the Commissioner of Crown Lands and Public Works, dated the 20th of April 1881, I embarked for Mossel Bay on the 5th of May last.

Starting on this journey, accompanied by Captain Harison, Conservator of Forests at the Knysna, I made an examination, from a Forester's point of view, following the route which had been pointed out to me, passing through George, the Knysna, Tzitzikama, Humansdorp, Port Elizabeth, Alexandria, Graham's Town, King William's Town, Pirie, Stutterheim, Queen's Town, Katberg, Kat river (or Stockenström), Graaff-Reinet, and Beaufort West.

Points for examination and report.

According to ministerial instructions, the points which I was required more specially to examine, and to which I should very carefully direct my attention, were the following :—

(1.) General management of forests ;
(2.) Methods of working ;
(3.) Conservation ;
(4.) Replanting ;
(5.) Preservation from fire ;
(6) Utilisation of timber ; and

generally whatever bears upon the creation, existence, preservation, and multiplication of trees.

Divisions of Mossel Bay and George.

The neighbourhood of Mossel Bay and the country which came under our observation in following the route to George, as well as the southern sides of the mountains which enclose the division on the north, are destitute of trees.

On approaching George, we passed many perennial streams, and noticed some small clusters of trees in the Kloofs forming

the sources of these rivulets. Three of these lots are inaccessible for working, but still form a part of the Crown lands.

Remains of old forest near George.

They are all that remain of an ancient and important Crown forest either sold, burnt, or to a great extent destroyed.

Before arriving at George, near to Blanco, there is to be seen a portion of Crown forest known as Keur Kloof, in extent about ten morgen, which was burnt in 1869. It is now covered with keur trees (*Virgilia capensis*, Lom.)

Keur Kloof forest.

Beyond Blanco, and proceeding eastwards, the south sides of the mountain contain trees, at first in small patches in the Kloofs, but afterwards in considerable and dense masses with scarcely any interruption.

Rainfall in George and Mossel Bay divisions.

In this region the amount of rainfall and moisture is greater than in the division of Mossel Bay.*

Trees in town of George.

At George trees grow vigorously: there are to be seen in the town fine specimens of the stone, maritime and Aleppo pines.

Groenkops Bosch forest, at present closed.

On the journey from George to the Knysna, along the postal route, there is, at a distance of half a mile, the Crown forest of Groenkops Bosch, 1,692 morgen in extent. About 900 morgen only of these are stocked with timber. As this forest contains chiefly trees too young for felling, it is very properly, according to the system in vogue, closed to working.

Bennett's forest.

Further on stands the private forest of Mr. Bennett, which extends from Kayman's river to the other side of Silver river, with an area of about 250 morgen which comprises part of a lot of ground of about 2,000 morgen which, we were informed, had been sold for £2,000.

Olifant's Hoek forest.

Proceeding further, we leave on the right side, and to the south, a portion of Olifant's Hoek, which originally comprised 1,298 morgen. Two hundred of these have been utilized for immigrant locations. Ten hundred and ninety-eight still remain the property of the Crown. Of this extent about 700 morgen are clad with timber. Half of this forest comprises, in its irregular and diverse kinds of timber, a remarkable quantity of workable trees.† The remainder was burnt in 1869. About one-sixth of the surface destroyed by fire is clad with keur trees, already furnishing a supply of spars.

---

* In the Report of the Meteorological Commission for 1879, pp. 23 and 65. it is stated that at Mossel Bay there were 101 days of rain, giving 14 81 inches; at George 147 days of rain, giving 36 44 inches.

† A tree is *workable* when it has reached its maximum of growth or of utility.

It would be very expedient to replant the spots from which these trees have disappeared. The soil is *almost everywhere fit for the growth of* stink-wood.

Replanting of above recommended.

This timber is much sought after on all sides, and the region of its production is extremely limited.

The postal road then passes south of the forest of Woodville, and continues for some two hundred yards in this direction.

Woodville forest.

This forest is partially wooded to an extent of 802 morgen. It contains some trees of very considerable dimensions, but the greater part of them are not workable. It would not be possible, without injury to the forest, to remove the old trunks* (when granting licenses for this purpose) except with a proviso for previously marking the trees, and looking well after *the workmen who cut them down.*

The portion not at present timbered is generally of a stony soil, and pending a further and more careful examination, it seems, at first sight, to be capable of being advantageously stocked with pines.

The neighbouring lot, known as the Diep river, is of a total extent of 1,373 morgen, of which 1,000 morgen are scantily wooded.

Diep river woodlands.

The Commission of Inquiry into Crown forests considered it practicable to place three families of immigrants within the boundaries of this lot, and recommended the establishment of a village of wood-cutters on the left bank of the Diep river.

A little further on is situated the allotment of Hooge Kraal Bosch, containing 1,023 morgen, 90 square roods, of which nearly the whole extent is timbered.

Hooge Kraal Bosch forest.

There exists a riparian dispute with the owner as to the southern boundary of this adjoining piece of land.

Particulars of riparian dispute *in re* Hooge Kraal.

The allotments adjoining Wolve Eiland, and those which border upon the rivers Karratara and Homtini in the Knysna division, raise an *important question of proprietorship.*

The title vesting the property of Hooge Kraal, for instance near the river Homtini, describes the eastern limit of this farm thus:—"The river *as shown by diagram.*" The plan, however, represents a straight line at some distance from the tortuous course of the river. This leads to the belief that, in accordance with the grantor's intention, we are to understand by the term "river," not the centre of the bed of the water-channel alone, but also the sides of the basin at the bottom of which the river is shut in.

* Old trees useless for felling.

This view seems confirmed by conditions in certain titles of lands including forest, which, in granting the ground, provided for the reservation of the timber.

Government reservations of slopes to rivers recommended.

In the public interest, in fact, the Government should remain proprietor of these slopes. It is the only means of keeping them clad with trees—a condition indispensable to the maintenance of the soil upon the rock beneath. The owners naturally claim by virtue of their title, without taking the diagram into consideration, that their farms stretch as far as the bed of the river. The officers of the Government, on their part, hold that the boundary ought to be the straight line shown on the diagram to which the title refers, and they enforce this condition on the ground.

Prompt settlement of above questions necessary.

It will be necessary for all parties that this question should be promptly decided.

Summary of extent of forest lots in *George division*, and remarks thereon.

Summing up the foregoing remarks, there are in the George division six Crown land lots containing timber. The total extent of these six lots is 7,918 morgen. Of these about 4,410 morgen are timbered, and 3,508 are not. About 508 morgen of the latter could be utilized for the purpose of immigrant locations, or for wood-cutters' villages; the remainder, say 3,000, are in no way fit for the production of timber.

Unsold mountain lots.

It would be proper also to examine if the mountain lots, which have not been sold, and which are absolutely unfit for agriculture, could not be planted with trees.

There are no isolated trees to be seen in the district, nor even along the water-courses, and not a single large enclosure by live fences.

Periodical burnings: evil effects on certain plants and trees.

The periodical burnings, which are the sole attention paid to the larger part of the soil of each farm, render impossible the development of plants of tardy growth, and cause the unceasing diminution, and even the wholesale destruction, of trees which originally adorned the kloofs comprised in these private holdings.

Forests now closed.

The 4,410 morgen of forest lands of this division are at present closed.

Precautions necessary when above are re-opened.

I am of opinion that the working of these forests should not be recommenced before measures are taken to conduct operations in such a manner as to ensure in future the uninterrupted growth of these forests.

Knysna division. Extent of forests.

The division of the Knysna comprises about 28,000 morgen of forest, 25,000 of which are distributed over a large number of Crown land lots already surveyed, the total area being 60,577 morgen. The remainder, situated near the mouth of the Groot river, and in the region comprised between this stream and Blauwkrantz, is estimated, approximately, at 3,000 morgen, and has not yet been surveyed.

Immigrant allotments.

Wood-cutting.

In the portions already surveyed, about 14,000 morgen have been judged suitable for the settlement of immigrants, or for the establishment of hamlets for wood-cutters.

Extent fit for forest culture only.

There remain 21,577 morgen exclusively fit for forest culture.

Inaccessible forest lots.

Of the 25,000 morgen of forest land, at least 5,000 morgen are inaccessible, either for want of a road by which to reach them, or because they are situate on the sides of declivities too steep to render it prudent to work them.

Reasons for trees on mountain sides.

The presence of trees is indispensable to the maintenance of the soil on the mountain sides, and their removal would occasion more or less considerable land-slips.

Extent of forest lots available for working.

Ten thousand morgen at least are available for working, and at many places all that which could have been utilized under present conditions is not now available.

Species of trees found in the forests, with their distribution.

The species of trees which compose these forests are generally distributed as follows, in the district of the Conservator of the Knysna (comprising the divisions of Knysna, George, and Humansdorp) :—

(1.) Yellow-wood ...	...	20	per cent.
(2.) Iron-wood ...	...	20	,,
(3.) Keur-wood ...	...	12	,,
(4.) Stink-wood ...	...	8	,,
(5.) Assegai ...	...	8	,,
(6.) Witte Els ...	...	4	,,
(7.) Essenhout ...	...	4	,,
(8.) Saffraan ...	...	4	,,
Vliers, White Pear, Boukenwood, Hard Pear, Red Els, Keur, Chestnut, Kamassi, Paardepis, &c.	about ...	20	,,

Determination of qualities, &c., of above woods.

The mechanical properties of these woods, such as resistance to tension, compression, flexion, twisting, closeness of grain, have to be separately determined in each case.

Proper times and seasons for felling.

Experience shows that they resist perfectly decomposition by decay and puncture by insects, provided they are felled when mature, and in the proper season, when the sap has ceased to rise; that is to say, from the time of fructification until that at which the sap rises in order to form the flowering buds for the following year. These periods do not all occur at the same time with all the species, as in Europe, but they come in succession in such a way that the forest is never in a state of repose.

The time of felling varies with the kind of tree, and for each description, according to the atmospheric conditions of the year and the district in which the trees grow.

Details of past periods of felling.

For instance, the periods during which felling was practicable *in the Knysna district, during 1879* and 1880, were as follows :—

Stink-wood	...	1879. February to the end of June. 1880. March to the end of July.
Upright Yellow-wood	...	Do. do.
Bonkenhout	...	Do. do.
White Pear	...	1879. November to February. 1880. December to March.
Saffraan	...	Do. do.
Iron-wood	...	1879. June to September. 1880. July to October.
Witte Els	...	May to September.
Essen-wood	...	June to October.
Assegai-wood	...	1879. July to October. 1880. August to November.
Outeniqua Yellow-wood	...	1870. November to February. 1880. September to end of February.
Red Els	...	September to January.
Vliers	...	October to February.
Kersenhout	...	November to April.
Wittehout	...	May to October.
Hard Pear	...	1879. December to April. 1880. November to March.

Results of felling out of season.

Trees cut whilst the sap is rising do not produce lasting wood, and when used for public works are damaging to the interests of the country.

Even when such wood becomes an article of trade, to say nothing of the wrong done to the persons who use it, the country suffers in reputation on account of the rapid decay of such wood casting discredit upon a Colonial product, and tending to create a preference for foreign timber, the latter being, however, inferior to native woods, provided the trees of this country are cut at the proper time.

It is impossible, therefore, to take too many precautions for ensuring the felling of the trees at the proper season.

Regulations for felling trees (Government Notice No. 361 of 1875), *Licenses, &c.*

The felling of trees is prescribed by Regulations (Government Notice No. 361 of 1875), in which wise provision is made to secure the best method in every respect. By the terms of these Regulations the Crown forests are open to persons provided with licenses to cut the different kinds of timber, during the season considered suitable by the forest rangers in charge, and at none other.

Mode of proceeding by licenses.

The price of the licenses and the kind and measurement of the wood composing the load which the license gives the right to cut, are clearly stated, and the manner of proceeding is, as nearly as possible, as follows :—

For instance, a person requires stink-wood, and procures a license ; for one load of 60 cubic feet he pays 30*s.* (thirty shillings).

Duties of ranger in regard to licenses.

He presents this license to the ranger charged with the custody of that part of the forest named in the license. The ranger registers and countersigns the license, and then returns it to the owner, who has, thereupon, the privilege of felling the timber specified in the license at the spot pointed out by the ranger. The wood when felled is inspected, measured and *marked by the ranger before its removal.* It is inspected a second time at the place where the wood is stacked for sale, and after that, the owner disposes of it as he thinks fit.

Contracts with Government, mode of execution.

On the other hand, when the Government requires a considerable supply of wood, for example, several thousand sleepers or telegraph poles, it makes an agreement with a contractor, and the latter executes the order in the portion or ward of the Crown forest which is pointed out to him, whence he transports the timber to its destination, and delivers it according to the price agreed upon.

Needs of original settlers.

The first settlers in a country have imperious and immediate wants. In the first place they must have wood.

Necessity for repurchasing in Europe certain forest rights.

In European forests many rights of usage have been conceded at the time when they then covered a large territory on which it was necessary to locate settlers. These rights became afterwards the source of so much trouble and caused such enormous loss to the State, that it was found necessary to repurchase them, no matter at how great a sacrifice of public money.

Action of original settlers in taking wood gratis from forests.

At the Cape, in the early days of its colonization, people took from the forests merely the wood necessary for dwellings, tools, fences, wagons, &c.,

Later settlers compelled to pay for wood taken from forests.

without troubling themselves about the future. A little later, those who took wood from the public forests were compelled at once to pay its value into the public treasury.

This was well enough at the time, and it was only just in fact that such a payment should contribute towards the funds, by means of which the Government carried on the public service, and that it should lighten, although but in a small degree, the charges imposed upon the community in order to make up the budget. Afterwards the Government made a fresh effort to infuse method into these matters, and hence the Regulations of 1875, which have brought about a great improvement.

Improvements considered.

I shall now consider whether it is possible and opportune to improve upon this system.

Original mode of felling and its neglect of necessary precautions.

In the olden times, if a man wished to build himself a house, he went to the forest as to an inexhaustible store from which he could be supplied gratuitously, where he looked around for a tree of a species, shape, and size suitable for his purpose, standing in a locality whence there would be little difficulty in transporting it. He felled it without troubling himself to ascertain whether it was still in active growth or had arrived at maturity, or whether he should clear the spot if a neighbouring tree of more advanced growth was stretching its branches over the space lately occupied by the tree he had just felled, and thus rendered impossible the development of any saplings. Thus, without taking any precaution to avoid injuring, crushing, or cutting the surrounding trees which, doubtless, rather interfered with the removal of the other tree, but which, though still starting into growth, would, in their turn, if properly cared for, become trees, the selected tree would be cut away at such a height from the soil that a portion of the trunk was wasted and the stump would yield no fresh shoots under favourable conditions. In selecting the tree the settler considered only the length of the timber wanted, and if the tree could yield more workable wood than he required, the remainder would be abandoned, wasted, and left on the spot, together with the head stump and branches.

The presence of such debris on the soil would probably result in preventing any young plant from developing itself in that spot.

The wood in process of decay would become a haunt of insects and a factor in rendering the blaze fiercer in case of fire.

Disastrous results of the foregoing.

In fine, there is nothing rarer than to see young and healthy trees, of valuable kinds, in localities where timber has been felled. Brushwood, creepers, and twining plants overrun the ground

and smother the few young and greatly-injured saplings, which, under such circumstances, can become nothing but useless and stunted trees.

In the second stage the settler is compelled to pay something to the Government in compensation for the wood which he has removed, but even then he leaves no less disorder in the forest after his departure.

Regulations of 1875 insure payment for wood felled.

By the Regulations issued in 1875, the Government is completely protected as concerns the recovery of the price for wood felled in the forest.

Information desired by the Government on conservation and felling, &c.

The Government is now desirous of knowing whether the Colonial forests should continue to be treated as if they were, as far as relates to the needs of a progressive community, in reality inexhaustible; and of ascertaining what can be done to improve the mode of felling trees.

Improper present mode of felling.

The general idea which prevails in respect of the felling of wood in the forest is even now that which originally arose from the necessity for satisfying the wants of the immediate moment.

Wasteful mode of felling.

When any one desires a load of timber, for wagon-building for instance, he procures a license which specifies exactly the quantity, kind, and price of the wood he is authorised to cut. At the spot pointed out to him in the forest, he selects the tree most suitable to his requirements. He does not choose such, and such a one, because it is too large, and because its transport and sale would not be so easily effected as those of a tree of smaller dimensions; nor another tree, although full-grown, because it has some defect; nor a third, because its removal would be a little more troublesome.

In fine, having obtained a license for a load of wagon-wood, for instance, he of course takes that which will suit his purpose best for the construction of a wagon.

The valuable wood in each tree is exactly measured; the license-holder pays his license money, and the spots where the trees have been cut are reduced to the condition I have just described.

Consequent disappearance of valuable timber.

When a forest lot has been thus denuded of its timber, it is closed, and left to nature's kindly offices to repair the disorder in which the place has been left. But in addition to this, as the forest district of Knysna, where the best timber of the Colony is to be found, still contains stink-wood, yellow-wood, and assegai-wood, the license-holders, having the choice, prefer taking these, particularly the stink-wood, rejecting the iron-wood and several other kinds of trees, which, though very useful, belong to an inferior class. Thus, when a forest section

is closed, it is because it has been deprived of its most valuable products, although it is furnished with workable trees, which have been passed over, either because they are too large, or because they are of a species of wood which, although frequently quite as good as that imported, is yet not quite so easy to work as that of neighbouring trees, which can be selected; and this goes on to the detriment of the forest. The old trunks encumber the ground and impede the growth of the best kinds of trees. The latter thus become still rarer, and will soon disappear from the districts where they are felled now, unless measures are taken to prevent such a deplorable consequence.*

Impending extermination of stink-wood.

There formerly existed in Europe a system somewhat analogous to this method, namely, the "Jardinage," which consisted in clearing away, here and there, the oldest trees, those decaying, diseased, or withered, and those of mature growth, required for the purposes of trade or for local consumption. As regards the future of the forests, this system is far preferable to the licensing plan, since it clears the soil at least of all mature trees, and thus provides space for those not full grown.

Comparison between "Jardinage" and the Colonial "License" system.

There are, however, certain disadvantages attendant upon this method† :—

Disadvantages of "Jardinage."

"The result of this mode of operation is that the forest presents to view at every point, trees of every age, mixed indiscriminately, from the young sapling to the old tree, and that the trees which attain the greatest bulk and height interfere with those placed immediately under their shade, and impede their growth; thus the latter, not having sufficient room, stretch out in branches and nearly always become knotted, and do not attain their natural height.

"The most feeble trees, stopped in their growth by those which overtop them, contract seeds of disease when this condition of overcrowding is continued; they nearly always languish, seldom arriving at a healthy maturity, and often they die.

"This 'jardinage' by extending the felling of trees over very large areas, renders its supervision difficult, and considerably increases waste in both felling and clearing. The greatest objection, however, which is consequent

* Stink-wood is now found only in the district—very limited in proportion to the extent of the Colony, bounded by Mossel Bay, the Outeniqua Mountains, Tzitzikama river, and the sea: although Dr. Pappe, in speaking of this species, says that it "grows in the principal forests throughout a great portion of the Colony." (*Silva Capensis*, 1862, p. 32.)

† *Cours elementaire des Bois. par M.M. Lorentz et Parade*, a work translated into English for the Government of India, (G. Huriot) (*Courrier Francais*, 5th August, 1865.)

upon this method is, that it does not enable the forests to yield, within a given period, any products but those of a nature very inferior, in regard to both quantity and quality, to those obtained by the natural method of propagation by seeds and thinning out.*

"In fact, in cultivated forests (jardinées), we see trees of every kind *restricted in their development for a time* of greater or less duration, and often, even to the close of their existence.

"In regular woodlands† on the contrary the growth is encouraged from its commencement, and stimulated up to the period of maturity, by periodical fellings under taken with this very object. Now it is evident that, of two forests, *that which will supply the most material* in a given time is that in which the generality of trees has the strongest and most sustained growth, other circumstances being equal.

"With regard to the quality of the trees, the facility which they have in cultivated (jardinées) forests to extend their branches, renders them inferior for constructive and *splitting purposes to those* which had grown in a wild state; and it is to be observed as well that the considerable waste caused by felling and clearing in such a forest, multiplies faulty trees such as are seldom met with in regular woodlands."

Probable beneficial results of application of "Jardinage" to the Knysna forests.

I think that if the treatment to which the forests of the Knysna are at present subjected were changed for that of a cultivation (jardinage), judiciously applied, their production of valuable timber would be more than doubled in a short time; and, if they were continuously treated in a rational manner, this production would doubtless double itself again; that is to say, it would be four times greater than it is at present.

Measures necessary for at once relieving the forests.

Precautions when felling.

However this may be, it is urgently necessary, by either one method or the other, to relieve the soil of full-grown trees, of perishing timber, and of trees belonging to species of second-rate quality, which occupy the ground unprofitably. In the second place, it is none the less essential, during the operation of felling, to clear the soil of debris and the young plants from the creepers and brushwood which smother them.

---

* "The method of natural renewal and thinning out consists of working the forests in such manner as will insure their natural and perfect re-stocking, by encouraging as much as possible their growth from their early youth up to the period of their felling."

† "A woodland is called regular when it exhibits in all directions a uniform and complete stock of trees, of ages suitably graduated, and when it contains *within itself all the elements necessary* for ensuring its natural reproduction."

The ways and means of doing this, which appear to me preferable, are set forth in the chapter in which I have grouped the recommendations in order to give shape to these measures as a whole, they being in the true nature of a careful organization.

Stink-wood, demand for and remarks upon the species.

The wood most inquired for is stink-wood (*Oreodaphne bullata*); it grows rapidly, but is very sensitive in certain respects. Its young shoots are so tender that the least contact with branches injures and kills them. It has as much need of air, light, and space about the head as of the zephyrs at its foot.

Stink-wood disappearing under present "licensing" system.

This species, however, would probably disappear from our forests if they continued to be worked under the licensing system, and if the young seedlings are depended upon as a means of replacing trees which have been cut down. But it possesses a singular property and one peculiar to itself.

Stink-wood, singular faculty of.

When a tree of this kind has been cut, not only does its stump send out shoots, but these again throw down roots, which descend the old trunk in such a way that, although the latter may decay, the original tree is replaced by one, two, or three branches which develop into veritable trees with roots to them.

Stink-wood, bad mode of felling and results on suckers.

Owing to the fatal custom of cutting trees at least three feet above the surface of the ground, these new shoots, resting on branches unable to find the requisite support in the original trunk, have not sufficient stability when the old trunk is rotten, and are thrown down by the wind before they attain a size sufficient to furnish timber.

By virtue of the faculty above described, in the districts which have never been worked, and where the want of light close to the soil has prevented the survival of the young plants, there are found old stumps of stink-wood perished through age, still standing upright, and encircled with a bundle of suckers sprung from their trunks and enrooted in the parent stump. It is possible, however, that these shoots from the stump attain neither the age nor the size of trees springing from seed.

When a plant of stink-wood has had the good fortune to spring up in a clearing,* and the rare luck of being neither too much injured by the fall of the neighbouring trees nor strangled by climbing plants, its growth is rapid, and everything tends to prove that a tree of this kind must have air and light from its very birth.

* A little place destitute of trees.

Stink-wood, scarcity of seed.

The seed of stink-wood is scarce and nearly always worm-eaten.

"The African Oak."

This tree has been styled by Mr. Barrow the African oak (*Chêne Africain*), which he has also likened, on account of its qualities, to the most valuable species of Europe. The oak in the east of France, and in several countries where it forms large forests, yields acorns in abundance every twelve years, but they are difficult to preserve.

Stink-wood timber, value of.

Stink-wood is worth at the Knysna from 4*s.* to 5*s.* per cubic foot. Planks of 20 running feet, one foot wide, by three to four inches thick, are worth from 20*s.* to 25*s.* each, and are sold at £7 10*s.* in the division of Stockenström.

Stink-wood now extinct in Stockenström division.

Stink-wood is not found in the forests of the latter region, although Dr. Pappe, in his *Silva Capensis*, states that it is found "in the primeval forests throughout a great portion of the Colony." Many localities appear to us suitable for its growth. Perhaps there is none of it, and it may never have appeared at all, in that district.

Reason for its disappearance.

Stink-wood, assegai, and witte els generally together.

But, on the other hand, the treatment which the forests have received from time immemorial in this respect would have been sufficient to cause its complete disappearance. It is generally found in company with the assegai-wood, or with the *witte els*, in the forests where it grows.

Stink-wood, possible re-production by cuttings; experiments in progress.

The property which the branches have of forming roots has led me to think that perhaps stink-wood could reproduce itself by cuttings, like the poplar. If this were so, the reproduction of this kind of timber would be abundantly assured. I have recommended experiments to be made with this object.

Yellow-wood.

The tree most widely spread, and that which attains the largest dimension in the division of the Knysna, is the yellow-wood.

"The African Pine."

If stink-wood is the oak of this country, we may say that yellow-wood is the pine. It appears but little in the habit of sprouting from the stump, but its reproduction from seed seems quite as general and easy as that of stink-wood is difficult and rare. Thus, in nearly all open spaces are to be seen saplings of yellow-wood, of all ages and dimensions, growing in the place of the felled trees.

Easy of reproduction.

Conditions favourable to its reproduction.

When these saplings have not suffered for any length of time, nor languished under the cover of large trees* nor have been too much injured by the removal of their predecessors (yellow-wood, having in only a small degree the property of throwing out shoots, appears to be unable to endure with impunity the severance of its limbs), nor are too much overshadowed by the branches of neighbouring trees, nor too closely entwined by climbing creepers, they often reach a size which places them beyond danger, and become timber-bearing trees. Otherwise they grow without sensibly increasing in *bulk*, becoming *hard* and *compact*, and *fit* for *excellent* spars or telegraph poles; but then they never become timber trees.

Yellow-wood, value of.

Larger trees should be selected.

Yellow-wood of middling dimensions is sought for in logs for carpenters' purposes, and is worth about 2*s.* 6*d.* per cubic foot at the Knysna. The largest trees would give excellent timber, but they are passed by on account of the trouble which would be necessary in order to transport them to the place of sale.

Why iron-wood, though plentiful, is little used.

It is the same with iron-wood. This wood† considered suitable for ship-building, and of which axles, poles, and tools are made, remains almost untouched in the forests of the Knysna, while there are imported into the Colony considerable quantities of wood intended for purposes for which iron-wood could be employed.

Its specific gravity and hardness, which render laborious its transport and its sawing by hand, explain this anomaly.

When means of transport improve, iron-wood should become much in demand.

It is to be hoped that when the Colony is provided with better roads for transport iron-wood will be sought for with an eagerness proportioned to its qualities.

Wanton waste of wood, caused by clearing the road through "Sourflat."

At present a road is being constructed passing along the district of Sourflat. The workmen have certainly cut much more timber than was necessary for the formation of the road.

The trees felled represent a very considerable value, to a great extent lost, because at the time of the actual cutting down there were no convenient means of removing them. The men cut off the best pieces in short lengths, which are quite

* A plant is said to be under "cover" of a tree when it is so situated that a portion of the crest or branches of the tree is placed vertically over it.

† According to a report by Sir John Coode to the Crown Agents, under date of the 21st of April 1877, *the result of the trials* (after immersion with regard to sample "iron-wood") *may be considered* "*as fairly satisfactory.*"

unserviceable, in order to throw them aside more easily, and the remainder is wasted on the spot.

How the clearing should have been done, with profit to Government.

If the workmen had limited their operations in the first instance to cutting the trees growing upon the roadway, or at the spots whence earth had been removed; or if they had even considered it necessary to afterwards clear away the timber from the sides of the roadway, considerable profit could have been derived from the wood, because there would have been room made for getting it away, so that even if the extent planted had not been further diminished, the Government would not have been deprived of the commercial value of material now wasted. But probably the workmen considered this too troublesome, and that the removal was necessary in order to prevent injury to the road by the proximity of overshadowing trees.

Road works: benefit of trees as consolidators of soil, &c.

It should have been borne in mind, also, that the trees standing on the sloping ground to the north would have done their part in contributing to the solidity of the embankments, and have been a protection to spans of oxen, and a means of security for loads and travellers.

In other countries, far from felling timber in those parts which command a line of road, haste is made to plant the embankments.

In this way also the trees stop the rubbish which the streams from the higher ground carry down with them, and also give security against the landslips always to be dreaded in newly-made embankments.

This line of road does not appear to have enhanced the value of the timber of the forest to such an extent as one would have expected, considering how much has been spent upon it.

Homtini road, remarks on construction of.

Timber is a product at once cumbersome and heavy, and the declivities are such, at certain points, as to render it difficult for heavy loads to be easily moved. Further, the crossing of the river Homtini is accomplished by means of a causeway and not by a bridge. In winter, at the time of floods, there are delays and difficulties in crossing, which increase the expenses of transport, and the inhabitants of the neighbouring division of George will, it is to be feared, still prefer importation by way of Mossel Bay, and other sources of supply to which they are accustomed.

The Main Road.

There is, moreover, in course of construction in this division, a route which will cross the Tzitzikama. It will give access to districts hitherto inaccessible.

Common woods of the Knysna forests.

I will not at present refer to the common kinds of wood in the district of the Knysna, beyond those which I have previously described. Not because they are without value—far from it—but either because these trees are in demand and their production is so easy that no precautions are taken with regard to them; or because they form so unimportant a part in the general mass of timber that they cannot seriously affect the future of the forests. What I have said of the principal kinds seems to me to render the actual position sufficiently clear to allow conclusions to be drawn from what I shall presently formulate.

Sleepers: Fox and Dunn's contract.

There are now two contracts in force for the supply of sleepers to be prepared in the division of the Knysna. One contractor, Mr. Dunn, undertakes to deliver 500,000 sleepers in five years, or at the rate of 100,000 per annum.

The place of felling has been selected in the district known as lots W and Y, which have never yet been open to the public. This spot appears very well chosen. The stock of trees comprises much yellow-wood, and but few trees of very large dimensions. The soil is firm and furnished with a young growth,* sufficiently mature. Here certainly there is a very favourable opportunity to encourage a young growth, the hope of the forest.

Mode of encouraging growth of young trees.

With this object we must uncover them by taking out all the mature trees which overtop them, but it is expedient to leave a certain number of trees of less age in a forward state of growth at convenient distances, which, without prejudicially covering the young growth,† shall yet cast upon them a salutary shade, properly mitigating the violence of the gusts of wind; and these will become timber-bearing trees when the natural plantation, which it is necessary to develop, can do without their protection. The young plants having the sun shining on their tops, and the trunks in the soil kept fresh by the thick foliage, will thrive under such favourable conditions, if assisted by the others. Every sapling, in order to thrive, requires a certain space in the ground, as much for extending its roots as it does in the air for spreading its branches; and according to the growth of a plant, the space which it occupies becomes necessarily greater.

"Cover" and "Shadow."

* *Seedlings*—A union of numbers of sprigs of seed from the ground.
Sprig from seed—A young tree which has sprung directly from a seed.

† The "cover" must not be confounded with the "shadow." The term *cover* means exercising an influence on the spot of ground which the top and branches immediately cover; it is constant in its injury to vegetation, by enfeebling the effects of light and rain, and by impeding the formation of dew.

All the plants composing the mass cannot, therefore, have sufficient space when each has arrived at twice its original size. Hence the absolute necessity of thinning out as trees increase in number and size. In such a case the young trees struggle with each other to obtain the space which is indispensable for a due share of light and air. In this struggle the weakest plants, deprived of this space, overtopped and pushed aside, will, in a very short time, in the same way as the smaller branches of others, wither and decay; and it is thus that from year to year the number of stalks diminishes, and those which survive, being more elevated and stronger, throw off their lower branches and produce stems themselves of greater length.

Thinning out, necessity for.

In the early age of the forest, this condition of things, far from presenting difficulties, offers great advantages; the young saplings afford each other mutual support against those overtopping them, and assist reciprocally each other's upward growth.

Thinning out unnecessary in early stage of growth of forests.

Subsequently the struggle increases, since those stems which are overtopped, although deprived of the influence of the light, take a longer time to succumb because they are stronger.*

At this juncture some of the sprigs are thinned out from the weakest, the sickly, and the mutilated, choosing among those which, although strong, are too numerous for a limited surface, and thus giving to the vigorous plants, which remain, the space necessary for their free development. This operation should be repeated a second and third time, whenever it may be requisite. Finally here, as well as in all countries where this plan has been adopted, I am confident we shall obtain a production of timber beyond comparison, as regards quality and quantity, with that which the soil at present furnishes.

Thinning out, proper times for.

Anticipated result of.

These explanations, then, of the manner in which it would be desirable to treat the forests, have been suggested by an examination of the portion to be worked for the furnishing of the before-mentioned supply of 500,000 sleepers during the next five years.

Another contract of the same nature is in operation in the division of the Knysna, but is applicable to a considerably less quantity. Mr. Jones has to deliver 25,000 sleepers. This supply will be taken from a district of the main forest near Plettenberg Bay.

Sleepers; Mr. Jones' contract.

* The "shadow," on the contrary, exercises its influence over a certain extent according to the different positions of the sun during the day. It is almost always *favourable* to the growth of trees, inasmuch as it tends to preserve a freshness of the soil and plants, without depriving the latter of the beneficial action of air and light. (*Parade; Culture des Bois.*)

Felling licenses for 1880—details.

Licenses for the extraction of timber, delivered in 1880, have been issued for the following quantities, *viz.* :—

Kinds of Timber.	Loads.	Cubic Feet.
Stink-wood	499	29,940
Yellow-wood	88	8,800
Witte Els	7	560
Wagon-wood	289	28,900
		68,200

Stink-wood most in demand.

From this it will be seen that stink-wood is five or six times more sought after than yellow-wood, and almost twice as much as the mixed woods which constitute loads of wagon-wood.

Wood-cutters.

Besides the wood-cutters, who have their working places about the forests, there are at the Knysna two steam saw mills in full work.

Steam Saw Mills, reduction in cost of sawing.

The cost of sawing by this means is from 20 to 25 per cent. less than by hand labour.

Colonial woods, reasons why so little is sold.

The reasons why so little Colonial wood is sold, are these :—

(1.) On account of the scarcity of stink-wood.

(2.) On account of the difficulties of the extraction and transport of the timber, considering the absence of roads in the forest and their insufficiency *beyond*.

Where and how disposed of.

The products are shipped at the Knysna, or at Plettenberg Bay for all the ports in the Colony: by land they are sent to the division of Oudtshoorn, the valley of Lang-kloof, and the neighbouring districts.

Knysna forests: value of produce in 1880.

The produce of every species taken from the forests of the Knysna in 1880 represented a value of £1,253.

Immigrant allotments.

Under the provisions of Act No. 33 of 1879, immigrant families are now being settled in the division of the Knysna upon allotments of Crown lands considered fit for agriculture.

Anticipated beneficial results of immigrant settlements.

The presence of a number of industrious men in the forest districts will doubtless produce a healthy competition, and the immigrants may, if they desire, obtain as wood-cutters abundant means and opportunities of becoming prosperous.

The firewood industry.

This European population will always find at hand the necessary firewood, and, as it increases, it will furnish in the future a certain outlet for products, which are now lying without value on the soil of the forests.

Reservations on immigrant allotments.

In proceeding to allot the ground, we should carefully reserve every mountain-side which commands a water-course, also on the bank of each stream a strip of land of sufficient breadth.

Cattle not to wander about mountain slopes.

The wandering of cattle over these hill-sides contributes to their denudation, and it is desirable to maintain a wooded condition in these parts.

Rainfall.

We have no accurate statistics with regard to the relative quantity of moisture with which this division is favoured. It is believed that the locality of greatest rainfall occurs between Blauwkrantz and the Storm river, and that with regard to both spots the mean quantity of rain is constantly diminishing both on the side of George on the west, and Humansdorp on the east.

Diminishing of above.

Reason for decrease of rainfall.

If this is the case, it would be sensibly in proportion to the wooded areas in the different localities of this region.

Experimental plantations.

Trials of plantations in the division of the Knysna have just been commenced.

To the north of the village, at a distance of about three miles, Captain Harison, the Conservator, has enclosed by means of spars a hollow of about ten morgen open to the south, from whence a small stream escapes. This ground presents mountain-slopes in all directions. The soil appears good, judging by the vigour of the plants which grow there, and a better spot could not have been chosen for beginning the work of tree-planting. On the right of the stream in the lowest part an extent of from five to six square roods has been roughly turned up and sown by drills with seeds of the stone-pine, which has formed a very good seed-bed. In another part of the ground you g oaks have been taken from a neighbouring property, as well as young stone-pines from the cultivated ground. The soil has been prepared to receive the plants by simply removing the grass, and digging the ground in patches of a foot square and distant about three feet from each other. The oaks have generally thriven, but not so the stone-pines. It would be better to sow the seeds in boxes, or, more simply and economically still, to start the seeds *in situ*.

Above should be continued; and reason for so doing.

I think there is reason to continue these experiments, and to find out by trial the most valuable kinds of Colonial wood.

Ultimate success certain.

The success, so far as concerns the ultimate wooding of this ground, is certain, unless it is set fire to.

In the division of George, the Knysna, and Humansdorp the space cultivated with cereals is very small: the remainder comprises waste land on which cattle are depastured, and the grass is renewed by setting fire to it periodically. By following this plan the growth of trees on these properties is impossible, so that absolutely none are seen in the country. The proprietor is quite content if he can save a few about his dwelling. From these useless pastures the fire spreads to the woody kloofs surrounding the farms, each time burning a belt of forest of a greater or less breadth, until the timber has been completely destroyed. This can hardly be otherwise, as things are now.

Cereals, space devoted to.

Effects of grass-firing.

Consequent disappearance of timber.

Occasionally fire originates in the forest itself, consumes the underwood, and chars the bark of the trees which wither very soon afterwards. If this timber were immediately felled it would lose nothing of its value, but those who take out licenses do not generally select it; thus, it decays on the spot, and, as a material, is absolutely lost. Generally the keur grows abundantly where these fires have occurred, taking the place of the burnt timber; until even this disappears in its turn when the forest is finally denuded, to an extent equal to that over which the fire has spread. Captain Harison has not allowed the question of these fires to remain without inquiry, and has made the following observations:—

Forest fires sometimes spontaneous.

Charred timber should be sold.

Ultimate destruction of burnt portions of forest.

Observations of Capt. Harison on forest fires.

(1.) They rarely commence in the forest.

(2.) Those which originate in the forest are not so dangerous as fires which proceed from a more general conflagration of the neighbouring parts.

(3.) In winter, when the ground is moist, the fire does not penetrate the forest.

From these facts he has concluded that by burning in winter the grass near the forests, and in thus keeping clear their borders, greater numbers of these disasters would be avoided.

Conclusions drawn by Capt. Harison, and measures taken by him to prevent forest fires.

This has been done in his division, and since the practice was adopted there has been no large destruction to deplore.

Results of such measures.

This is an excellent arrangement. In perfecting this practice by others, which will be indicated further on, I think that in a great measure these disasters will be avoided, and we shall succeed in remedying in a prompt, economical, and efficacious manner the bad consequences which could not have been foreseen.

Division of Humansdorp.

Extent of Crown forests.

The division of Humansdorp, comprised in the same forest district, contains about 18,000 morgen of Crown forests.

Inaccessible portion.

The portion situate between Blauwkrantz and the Storm *river is inaccessible to wagons, and has* never been surveyed.

Mode of estimating the area of the forests.

The area of the forests which are found there has been roughly estimated by squaring their perimeter, so far as could be done at a rapid inspection.

The contents of the forest are similar to those in the Knysna.

Stink-wood fairly plentiful.

Stink-wood is fairly plentiful in certain localities, but there remain, so to speak, but few more fellable trees of the kind in the forests where it has been possible to cut them.

Stink-wood saplings; the only spot where they appear to thrive.

Between Storm river and Captain Harison's house it appears to be found in the conditions most favourable for its production, and there only have I seen saplings of 5, 10, 15 and 20 years old which promise to become trees in their turn.

How above saplings are being injured.

Here again it is to be deplored that they should be injured by their old neighbours, the iron-wood and the witte els, (excessively widespread at their heads), which, under the existing license system, would occupy for ever the greater portion of the soil of these valuable forests.

Finest site for production of stink-wood.

This is the finest field for the production of stink-wood which can be found in the whole of the Colony.

The Government is still the owner of a great portion of the forest land in this division.

Government reservations to be made when these lands are sold.

When the Government shall judge the time to have arrived for selling these lands, it will be necessary to reserve the hills, steep slopes, and sufficient spaces for the production of stink-wood.

Small holdings, propriety of.

It would be desirable also, instead of continuing to create *such large lots, of which a proprietor can*not, at most, work more than one-fiftieth of the total area (the remainder being simply burnt as a means of culture), to endeavour to institute small holdings. The possessors of these small domains should cultivate them entirely, and thus a larger population would arise in this district. An alienation by means of very small lots would enable us to attain this object, and would fulfil the wishes and needs of many people, and secure a considerable gain to the public revenue.

Above would support a larger population.

Humansdorp forests, value and details, &c., of produce in 1880.

The production of the forests of this division, in the year 1880, amounted to £467. The licenses issued for timber were as follows :—

Kind of Timber.	Loads.	Cubic Feet.
Stink-wood	330	19,800
Yellow-wood	40	4,000
Witte Hout	7	100
Wagon-wood	94	9,400
		33,300

Stink-wood and yellow-wood most in demand.

Here also there have been felled five times as much stink-wood as of the yellow-wood, and twice as much stink-wood as of the mixed wood for wagons.

Possible yield or capability.

In order to understand exactly the material existing in the district of the Knysna, and that which could be disposed of without exceeding the limit of production (possibilité),* it would be necessary—

Measures for ascertaining above.

(1.) To make an inventory of existing trees.

(2.) To ascertain the average age at which each species arrives at maturity.

These two measures are indispensable.

Let us take a district under average circumstances, in which no wood has yet been cut. The trees are counted, the cubical contents are measured, and supposing a total of 100,000 cubic feet is found, and it is known that the trees are fellable, say, when they are 100 years old, for example, then—

Since this ground has produced 100,000 cubic feet in 100 years, its average yield has therefore been 1,000 cubic feet per annum. If, then, 1,000 cubic feet are felled every year, and if the cutting is done in such a way as not to restrict the growth of the trees, there will be found the same quantity to cut every year. Therefore, 1,000 cubic feet is the capability of production of the forest.

If the work is done in such a way as to facilitate the growth

* By *possibilité* is meant the proportion of the material which can be drawn annually from a forest, under the condition of maintaining a constant production, as far as possible—a result which we express by the term of a sustained production. (*Parade ; Culture des Bois*).

Bearing of proper and improper felling upon the annual yield of a forest.

of trees, there will be eventually a greater number of trees to fell, and the capability should then reach 1,200, 1,500 or 2,000 cubic feet, instead of what is produced in its natural state. If, on the contrary, the felling hinders the development of trees, the capability will decrease to 900, 800, or 700 cubic feet, and then the forest will be ruined.

Periodical inspections necessary.

Periodical examination would be necessary in order to ascertain if the system adopted is good.

In districts where timber has already been felled, the operation would be a little more complicated and the problem rather longer in course of demonstration, but it could be easily arrived at. This is not indispensable here, for we already see clearly that at least the two elements above pointed out should be kept in view, *viz.*, an existing content, and the age at which the trees should be cut. There should, without doubt, be an enumeration of trees, but this will take time, and we must consider it as of the first importance to gain, as soon as possible, a knowledge of the resources of the forests of the Colony.

Knowledge of resources of the forests of primary importance.

We have gathered information from men accustomed to frequent the forests, and have corroborated their opinions by making calculations upon a small extent of twenty square yards, when such area appeared to us to represent the average extent of a plantation.

Information on above; how obtained.

Captain Harison has also very kindly caused this to be done by rangers under his orders, who readily assisted with zeal and good will.

From these data we roughly estimate the yield of utilisable timber of every kind to be about 500 cubic feet per morgen, or say 25,000,000 cubic feet.*

Knysna forests: Total estimated yield and value of products.

Of this total, the proportion of stink-wood is not at present more than four per cent., or approximately 1,000,000 cubic feet, and it is almost entirely situated in districts which have never yet been worked; but it is easy to understand that in making a clean sweep there will be nothing for a long time to come, if indeed such a proceeding does not result in the complete disappearance of the forests.

Threatened extermination of stink-wood and of the forests.

This would be analogous to the proceedings of a grazier, who should take it into his head one day to kill or sell all his

* It appears from my researches that the total surface of the forests of the district of the Knysna is in round numbers about 50,000 morgen.

The extent of these forests has been shown in the return presented to Parliament in 1878, in reply to questions relating to Colonial timber, and estimated at 240 square miles, say 72,500 morgen; but it has doubtless been included in the total of portions sold, burnt, and absolutely inaccessible.

cattle, *viz.*, oxen, cows, calves, sheep, horses, asses, mules, colts, and fillies, and who in making a fresh list of his stock should count upon the very young animals which had not attracted his notice, or were too sickly to have tempted him to such a foolish day's work.

Mode of ascertaining when trees reach maturity.

In order to judge of the age at which trees arrive at maturity, and consequently the period required for the production of a corresponding yield, we should, in default of previous observations, have to examine and count the concentric rings of a large number of trees felled under various conditions. Captain Harison has been requested to do this.

Probable age at maturity.

Pending further investigations, from what I have seen, and also from the unanimous opinion of persons of experience whom I have questioned, I have reason to believe that the trees arrive at maturity between 80 and 100 years. If we adopt 100 years as the age for felling, the quantity to be taken annually, that is the actual yield, would be $\frac{1}{100}$ of 25,000,000, or say 250,000 cubic feet; and if we adopt 80 years, then it would be $\frac{1}{80}$ of 25,000,000, or 312,500 cubic feet. If we reckon on 300,000 cubic feet, this is certainly very near the truth, admitting that every forest would be accessible.

Annual yield; mode of arriving at estimate.

But, as we have before remarked, there exists a considerable stock of old trees, of which it would be well to clear the soil. There should be a reserve fit for felling that may be estimated at 5,000,000 cubic feet, and that can be combined with the amount of capability so as to satisfy actual needs.

Trees in reserve.

These valuations are given for the purpose of merely contributing to a general statement.

It must be borne in mind that the yield of every forest must be distinctly and rigorously ascertained, and that the treatment which it should receive must be specially adapted to it.

Yield and treatment.

Products of the Forests of the Forest District of the Knysna in 1880.

Division.	Stinkwood.		Yellow-wood.		Witte Els.		Witte-hout.		Wagon-wood.		Telegraph Poles.	Railway Sleepers.	Poles.	Spars.	Keur Spars	Dry Fire-wood.	Remarks.
	Loads.	Cubic feet.	Loads.	Cubic feet.	Loads.	Cubic feet.	Loads.	Cubic feet.	Loads.	Cubic feet.	Pieces.	Pieces.	Loads.	Loads.	Loads.	Loads.	
George ...	6½	390	...	...	...	...	...	...	1	15	... ..	.....	...	7	99	55	Stink-wood free for Divisional Council of George.
Knysna ...	499	29,940	88	8,800	7	560	...	...	194	19,400	4,168	710	4	21	9	46	
Humansdorp ...	330	19,800	40	4,000	...	...	1	100	94	9,400	.....	.....	...	10	2	...	
	...	50,130	...	12,800	...	560	...	190	...	28,900	.....	.....	...	...	...	101	

(*To be continued.*)

PRODUCE IN CASH.

Total amount of Licenses issued ...	...	£1.710 15 0
Estimated Market Value of Timber felled ...	...	15,193 5 0

PRODUCE IN RAW MATERIAL.

1. *Timber*—			*Cubic Feet*	110,152
Stink-wood...	...	...	... 50,130	
Yellow-wood ...	...	...	... 12,800	
Witte Els ...	...	...	... 560	
Witte-hout ...	...	...	... 100	
Wagon-wood ...	...	...	... 28,900	
Telegraph Poles, Spars, Sleepers, &c.			... 17,662	
			110,152	
Dry Firewood	...	...	Loads ... 101	

Flowering of the Australian Wattle on the Nilgiris.

By D. Brandis.

At this season the Australian wattle on the Nilgiris is covered with flower buds, which are arranged in large panicles at the ends of the branches. These buds take a long time before they open, and only a few trees here and there, or rows of trees, are now in full flower. Most of the trees in flower are small, and all the rest are, and have, since last month, been in bud. When talking over this remarkably slow development of these flowers with Major-General Morgan, he gave me an account of the introduction of this tree on the Nilgiris. General Morgan was for many years in charge of the forests and plantations on these hills, and his remarks on this subject, which I give, as he kindly sent them to me, will, I feel sure, interest the readers of this Journal.

I may add that in the equable climate of these hills, several shrubs and trees seem to have a much longer flowering season than elsewhere; thus the two brambles, which the Nilgiris have in common with the North-West Himalaya (*Rubus flavus* now called *ellipticus*, and *Rubus lasiocarpus*), have been in flower from the middle of March until the middle of June, and *Rubus lasiocarpus* is in flower still, while for instance near Simla a fortnight or three weeks at a certain elevation is the usual time of flowering. *Rhododendron arboreum*, also, which, though called *nilagiricum* by some botanists, is the same species as the common *Rhododendron of Northern India, continues in flower much* longer here than near Simla. It will be understood that I am speaking of trees growing at the same elevation, and otherwise under similar circumstances.

Generally, it may be said that many shrubs and trees have a remarkably long flowering season on the *Nilgiris, and I believe* that this has long ere this attracted the notice of botanists. A beautiful Myrtaceous shrub, (*Rhodomyrtus tomentosa*) which is common all over the plateau, at elevations above 6,000 feet, has now been in flower ever since March, and on the same shrub will be found the ripe berries (which are eaten) as well as buds and flowers.

Regarding the wattle General Morgan writes as follows:—

"*Notes on Acacia dealbata.*"

"This tree was introduced on the Nilgiris before the year 1845. Colonel Dun, the owner of many houses in Ootacamund, had planted several trees in his compounds probably several years before 1845, but the tree was by no means common, and as late as 1855 was sold at the Government Gardens at two annas a plant. A curious fact regarding the flowering of this tree has been observed:—*In 1845, and up to about 1850, the trees* flowered in October which corresponded with the Australian flowering time; but about 1860 they were observed to flower

in September; in 1870 they flowered in August; in 1878 in July; and here, this year 1882, they have begun to flower in June, this being the spring month here corresponding with October in Australia. All the trees do not flower so early, because at various times seeds have been imported from Australia, and the produce of these would of course flower at the same time as the parent trees in Australia, until acclimatised here.

"Having watched the flowering of these trees for nearly forty years, there cannot be any doubt in the matter; and it is a curious fact that it should have taken the tree nearly forty years to regain its habit of flowering in the spring. Commencing in October, our autumn, it has gradually worked its way back to summer, and finally to spring; probably it will remain at this point. On arriving in Ootacamund in the flowering time the stranger cannot fail to be struck with the golden appearance of the trees, clothed with blossoms of the purest yellow. Indeed it may be said to be our only conspicuous tree flower; for, though the *Eucalyptus* has its pretty white blossom, the amount of flower is small in comparison with the foliage."

The Forests of Ceylon.

By F. D'A. Vincent.

The general public probably gets its idea of Ceylon by a short stay on the western side of the island, when the steamer touches at Colombo or Galle, or perhaps by the account given of the climate by some relation who forms one of the large *and important community of coffee planters, with estates in* the centre of the island. The climate and vegetation of the greater part of Ceylon are so different from those of the western coast and of the coffee districts, that I shall first give some idea of the distribution of the rainfall before mentioning the forest vegetation.

The island is exposed to the full force of the south-west and north-east monsoons; and, as these monsoons blow for eight months out of the twelve, it would be natural to suppose that the rainfall is both heavy and equally distributed throughout the year all over the island. This, however, is not the case. The south-west monsoon, breaking generally about the middle of May, passes over two-thirds of the island without more than a passing shower, the principal rainfall of the island being that brought by the north-east monsoon.

If the reader will examine the map of Ceylon he will find in the centre of the southern-half of the island some ranges of hills extending from Kandy southwards to the Moruwa Korle, within 30 miles of the sea. These ranges of hills, about 60 or 70 miles long, form the eastern boundary of the area

affected by the south-west monsoon. All parts lying to the south-west of these hills share more or less in the downpour, whilst the rest of the island only benefits by an occasional shower. The effect of these ranges of hills is most remarkable, and is probably due to their arresting the course of the clouds, and forcing them back towards the sea. In Colombo, which, it will be seen, is south-west of the northern limit of the hills, the average annual rainfall is 87 inches, whilst at Negombo, 18 miles further north, and rather further from the hills, the rainfall is 66 inches. At Chilaw, only 42 miles north of Colombo, and quite out of the influence of any hills or other obstacles to arrest the course of the south-west currents, the rainfall sinks to 48 inches. On the southern coast the same effect is noticeable. At Galle the rainfall is 90 inches, whilst at Hambantota, 70 miles to the east, in the extreme south-east corner of the island, across which the two monsoons sweep, the rainfall is only 20 inches.

The north-east monsoon begins in October, and, lasting till February, distributes its rainfall over the whole of the island, those parts to the north-east of the central mountain ranges naturally receiving most. The hills do not, however, as in the case of the south-west monsoon, protect the lee side of the island, for, at Colombo and on the western side of the island, the winter rains are often the heaviest and most continuous.

The moist zone, or that affected by both monsoons, is therefore comprised within lines drawn south from Kandy to Matara (about 100 miles), and from Kandy to Colombo (about 60 miles). Within these lines and the sea the rainfall varies from 60 to 230 inches, the average being perhaps about 90 inches.

The rest of the island, or the dry zone, is affected only by the north-east monsoon, the rainfall varying from 60 inches on the eastern coast to 30 and 20 inches at Manaar and Hambantota, the average annual rainfall for the greater part of the area being about 45 inches.

It will, therefore, be seen that the climate of the greater part of Ceylon presents a vast difference from that of the western parts most visited by Europeans. The limits of the moist and dry zones, which have been thus roughly defined, correspond with the limits of two very distinct floras—that of the moist zone is very similar to the flora of the Malayan Peninsula, whilst that of the drier parts of the island resembles in many respects the flora of the Madras mainland.

As regards the forests I may begin by saying that all the forests are evergreen; there are very few deciduous trees, and none of them form any important part of the forest growth.

In the moist zone there are few forests left of any extent, comprising the only parts of the island which are thickly populated. Very large areas of Crown land have been sold for

plantations of coffee, cocoa, tea and other "new products," also for paddy cultivation. Some of the most important forests have also been sold to private persons, who are to work out the timber and sell it in Galle or Colombo.

The forests, which are still the property of the Crown, form only small isolated blocks. In the moist zone the forests do not generally contain much valuable timber. With the exception of Calamander and Nedun (*Pericopsis*) there are no very valuable woods, but with easy water carriage to the coast, all the softer timbers find a ready sale for in-door work, and for coffee cask staves. The principal woods in these forests are:—*Doona zeylanica, Artocarpus nobilis, Carallia integerrima, Dillenia retusa, Vateria acuminata, Dipterocarpus zeylanicus, Careya arborea, Melia dubia, Pericopsis Mooniana*, several species of *Eugenia, Diospyros quæsita*. The last, Calamander wood, was formerly common in the wet forests with a rainfall of 120 to 150 inches. For cabinet work it is one of the most valuable, but the tree is now almost extinct. Pieces only fit to give planks four inches broad are said to have been sold at the rate of Rs. 400 a ton, and it is difficult now to get even a specimen of this beautiful wood.

Timber work at present is principally directed to the dry zone, where there are still very large areas under forest. In the northern-half of the island, and in a great part of the eastern province, the population is very scattered; villages are very far apart, and probably not more than one hundredth part of the area is cultivated. The rest of the country is more or less covered with evergreen forests, and with tree scrub. The principal forest trees are:—Satinwood (*Chloroxylon Swietenia*), Ebony (*D. Ebenum* and *D. Melanoxylon*), Trincomali Wood (*Berrya Ammonilla*), *Mimusops Elengi, M. indica, Alseodaphne semecarpifolia, Vitex altissima, Calophyllum tomentosum*. These form the saleable woods. They are mixed up with a very large proportion of woods which are at present worthless, and almost unsaleable. Most of the forests usually consist of the commoner kinds of wood, with the saleable woods sparingly sprinkled amongst them. The only valuable trees which anywhere form a fair share of the standing stock are Trincomali wood, Satin wood and *Mimusops indica*, and with these it is only in the most favorable situations that any one species forms one-sixth of the standing timber. The following are some of the commoner kinds; some give very fair timber, but there is at present only a demand for the better kinds of wood mentioned above:—

Schleichera trijuga, Strychnos Nux Vomica, Ulmus integrifolia, Acacia leucophlœa, Diospyros Embryopteris, D. ovalifolia, Terminalia Arjuna, Phyllanthus Emblica, and very many others, such as *Stephegyne, Adina, Dysoxylon, Pterocarpus, Cassia*.

A tree forming a very remarkable feature in nearly all

the drier forests is *Hemicyclia sepiaria*. It often forms one-third or even more of the forest, and with its irregular fluted trunk has a very peculiar appearance in large masses. The wood is useless.

The forest soil is generally sandy, poor, and of no great depth, with an underlying rock of gravel, quartz or gneiss. Under the taller trees there is usually a dense scrub, consisting of seedlings of the inferior woods, and of other shrubs, and growing to a height of six feet. With the larger trees over head and the undergrowth, the soil is completely protected from sun and wind, and its natural poverty is less apparent when enriched by thick layers of leaves. Grass is rare in all the forests, and consequently forest fires of any extent are unknown.

Since 1873 the forests have been principally worked by direct Government agency, but previous to that permits to cut timber were issued to traders on payment. With defective supervision, it is scarcely necessary to add that immense harm was done; we now find that the traders succeeded in clearing most of the forests within 25 miles of the seaboard. There is reason to believe that very large thefts of timber took place, but worse than that, the natural reproduction of the better species has been almost at a standstill for the last 30 years. It is difficult to arrive at the real cause of this, but it is possibly due to the fact that the ground was, at the time of the felling, already stocked with seedlings of the commoner kinds of timber. These had been forming the undergrowth for years, only waiting for the opportunity, which the clearing gave, to spring up into vigorous growth.

The forests have, however, a still greater enemy to contend with. Chena or Hen, the Ceylon representative of the Indian Kumri, Jhoom or Tounggya, has perhaps done more harm here than in any other part of the east.

A scanty population of Singhalese and Tamils, decimated by disease and famine, and too indolent to undertake paddy or any other form of permanent cultivation, have, for the last fifty years, been engaged in devastating thousands of square miles of the finest forest in the island, to secure one or two crops of millet or Indian corn. The soil after being abandoned becomes covered with a very dense scrub of *Dichrostachys cinerea*, *Phyllanthus Emblica*, *Zizyphus* (four species) *Carissa*, *Dodonæa viscosa*, and other similar species. This scrub grows about 20 feet high in 15 to 25 years, and then remains until the cultivator returns to clear it again. This he avoids doing until he has exhausted all the available areas of rich forest land; and, as he can generally manage, even now, to find some forest which has never been cleared before, it is rare to find old chena land brought into cultivation a second time. Except on the east coast, grass rarely comes up on

chena clearings, so, when seen from a height, the general appearance of the country is most deceptive. Old chena scrub has the appearance of forest, so that looking from one of the many isolated hills of bare gneiss which are so common in the north-east of Ceylon, the ordinary observer would think he had to deal with one vast forest instead of with a sea of chenas, dotted with a few islands, the remains of old forests. Chena cultivation, and the devastations of the traders combined, has only left the remains of what 30 years ago must have been magnificent forests. The work of restoring these remnants and restocking the forests with the better woods will, I fear, take more than double that time to accomplish.

A large portion of the forest produce is exported to India, China and Europe. India takes Trincomali wood for its gun-carriage factories, for the Madras masula boats, &c.; satin and ironwood for building; palmyra for rafters (cut at present in private lands); *Calophyllum tomentosum*, for poon wood masts and spars; and some firewood.

China takes ebony, the blackest wood only, and of this Ceylon has the monopoly. For the best black ebony the price usually is Rs. 120 to Rs. 140 per ton in Colombo. Satin wood and ebony are sent to England, the English market being less particular than the Chinese as to the color of the latter.

Notes regarding the Cultivation and Propagation of the Paper Mulberry in Japan.

By T. Tanaka,

Chief of the Agricultural Bureau at Tokio.

The paper mulberry is a deciduous shrub which grows to seven or eight feet high in its natural state. In cultivation it rarely reaches higher than five or six feet, in the form of a bush, because it has to be cut annually. Its leaves are four or five inches long. It can be cropped after four to five years from the time of planting, and then will annually yield a supply of fibre for paper pulp.

It is propagated by layering, division of roots, cuttings, and by sowing, but the last method is slow and not usually practised.

Layering.—In the latter part of March the ground is dug around the plant, light manure is applied, and the young twigs are then layered down in the ground which has been previously dug. They are then covered with earth three inches thick, leaving only the tops of the twigs out of the ground. In the following spring, when small roots grow from the twigs, the layers are cut and planted in prepared ground, on small mounds about 18 inches apart, from which new shoots sprout in about ten days after planting. By September they often have reached a height of three feet.

Propagation by division of the roots.—After the twigs have been cut for pulp, some of the mounds on which grow suitable plants for propagation during the next year, are deeply covered with earth, and in the next spring season new shoots sprout from the hill. They are then taken up and the roots separated and planted in the nursery ground, and after three years they are transplanted to the fixed ground or field, and are fit for cutting after another year..

The method of planting and cultivation.—The young plants may be planted on high ground, on mounds, or in fields, in March or April. In June they must be carefully weeded, the dry weeds being piled around each mound on which the plants are growing, for they make a good manure.

The harvesting of the plants may take place any time during the season when the plants are deciduous (from September to February). The manner in which they are prepared for pulping is the same as for mulberry plants, as usually practised in Japan, and the average amount of the annual harvest of pulp has not yet been ascertained, as it differs considerably in different provinces.

There are eleven or twelve varieties of the plant, besides which there are five varieties of the wild species, which are used for

making paper of inferior quality. The *Broussonetia Kazinoki* and *B. Kaempferi* also belong to the same genus.

[*Note.*—By Dr. Brandis' kindness the rooted cuttings of *Broussonetia*, sent from Japan, were sent to us in Darjeeling. As they looked so feeble on arrival we had them planted at once, and we are glad to say that they are sending out good shoots. When better established, they will be moved to the Terai, as the winter frosts in the hills would perhaps kill them.—*Ed.*]

Ripening of Deodar Seed.

By D. Brandis.

I have read with great interest the remarks regarding the time which the cones of deodar require to ripen, by Mr. A. Smythies in the January number, and by Mr. McA. Moir and Mr. Wilmot in the April number of the "Forester."

I may mention at once that when, after publishing the Forest Flora, I returned to India in 1874, and found more opportunities than I had previously had of watching the habits of the deodar, I felt doubts regarding the statement on page 517. I made a note in my copy of the work, and I probably mentioned it to my friends; but other matters occupied my attention, and I never systematically followed up the subject.

The observations now recorded seem to establish it beyond doubt that in the Jaunsar and Bhagirathi forests the cones of the deodar, as a rule, require one year only to ripen, and this is a most important result; but I feel sure that I have seen half-mature cones on the tree in autumn, together with ripe cones, and it is quite possible that there is a certain irregularity in the habits of the tree which requires further research. Continued observations in different parts of the Himalaya, similar to those already published in the "Forester," will doubtless set this important question at rest.

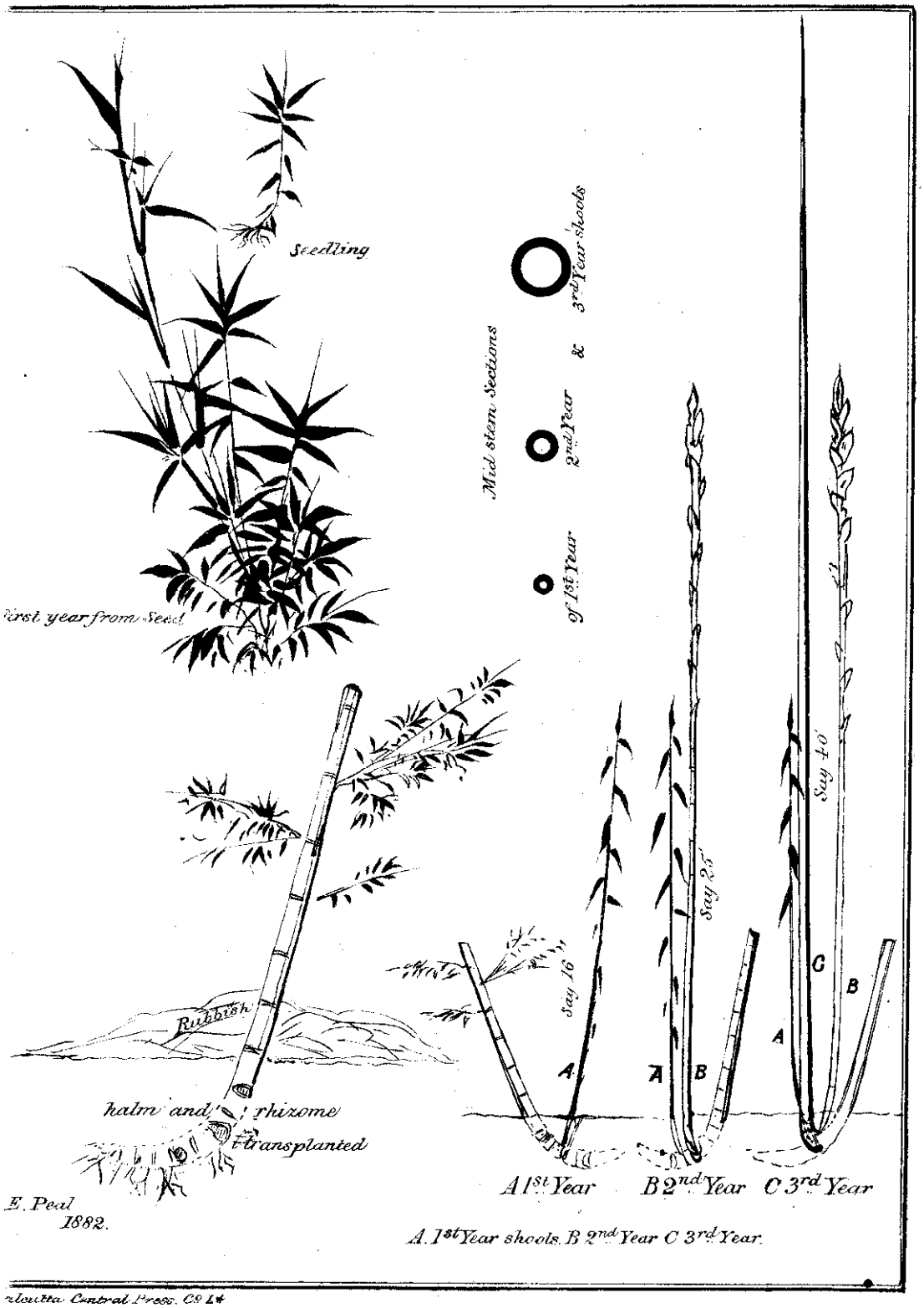
I may add that I have not succeeded in coming to a definite conclusion regarding the habits of some other coniferous trees, and particularly regarding the time which the cones of the Khasia pine require to come to maturity. I had studied the tree many years ago in Burma, and had stated my doubts on the subject on page 508 of the "Flora." I again took up the matter while on the Khasia hills in 1879, and again while on the hills between the Sittang and Salween rivers in 1880, but was not able to satisfy myself on the subject. The "Indian Forester" will, I hope, be the means of clearing up the uncertainty which still exists regarding the habits of some of our coniferous trees in India. The publication of a handbook, like the "Forest Flora," was a sort of first venture, intended to pave the way for future progress. Many of the conclusions recorded in that book were necessarily based upon insufficient data; and, as observations are multiplied and made over a wider range of country, these conclusions will be corrected, and some of them will be thrown overboard. But this is the only way in which progress in a scientific profession can be made.

Bamboo for Paper Stock.

TO THE EDITOR OF THE "INDIAN FORESTER."

SIR,—I trust in fairness you can allow me a little space to show your readers and Mr. Routledge that his attack on me in your April number was unjust, and due to his want of a "little" of the knowledge that he warns me is a dangerous thing.

With a little *more* knowledge I am sure he will see his mistakes, so with your permission I will ignore the personalities, and say as little as I can of them while giving all the information I can that may interest others.



Calcutta Central Press. Co. Ltd

Most of the mistakes made by Mr. R. arise from a habit many writers have, himself included, of making no distinction between *stems* and *clumps*, when the "age of bamboo" is alluded to. Thus the age of the common "jati bans" *stems* run to about twelve years, while that of the *clumps* is about eighty years. This alone will account for most of the seeming contradiction I am credited with, and it must be of course confusing to one who has "never visited any country where the bamboo grows naturally." There is another matter regarding the growth of the *stems* that Mr. R. is unaware of. I see he says, "the young bamboo sprang from the seed of the old plant, and took fifteen years to become silicious" (whatever that means) and "went on maturing for a series of years * * till the inside got filled up, and it could grow no longer, no longer transmit sap, became ossified, and died, having first seeded."

In the above there is hardly one item correct as you doubtless know.

Firstly.—Not a single full-sized bamboo stem ever grows from a *seed*.

Secondly.—Neither *stems*, nor clumps, mature or become silicious (?) in fifteen years. In most kinds the *stems* are mature and fully grown, and often die before fifteen years; and the *clumps* (in the clumped kinds) generally mature and flower at from twenty to eighty years.

Thirdly.—The inside does not gradually fill up, become ossified, and unable to transmit the sap. At times the inside is filled with water or deposit of other kinds, one joint in say 10,000. The hole inside does not become smaller after the first year.

Fourthly.—An individual stem never seeds by itself. When the seeding takes place all the stems from one year old to twelve or fourteen that are alive, seed *simultaneously*—an operation rarely seen. When a clump seeds the seeding is *general* (or seems to be so here for most kinds of bamboo), and the phenomena is seen all over its habitat. The charges Mr. R. brings against me, of inconsistency, &c., are due to his want of practical knowledge of the various kinds of bamboo in their habitats.

I may mention that the kind called "jati bans," so common in all Assamese and Bengali villages, is called so here because it is the best kind or "jat," and as we see the word in "jati plantain," "jati bet," &c. My "ignorance" in regard to planting it from seed up here is due to the fact that I have been here only 18 years; and though I have made frequent enquiry from old village elders, I have never met one (so far) who remembers this kind seeding. Indeed all maintain it does *not* seed. It has not done so here seemingly for over 60 years, so what could I do? When I planted two large baries (or enclosures

of bamboo) I perforce had to do what every one else did, and put in the stems and root, and this has been described before in your magazine I believe. When a bamboo seed falls and germinates, it comes up like a shoot of grass; other shoots coming out from the eyes at the ground during the first year. In the second year fresh and larger shoots rise from near the ground, and in some kinds their whips are thrown up. The seed, never directly and in the one year, gives rise to a so-called "bamboo," or *full grown stem.*

In the third year of most kinds a crop of long stems rises nearly simultaneously, while a good deal of foliage springs around the original shoot and offshoots, from the *eyes* in which these stems arise. In the "jati bans" the first whips of second year may be 16 feet high and an inch thick, nearly solid, and are not called bamboos.

The shoots of the third season may run up 30 feet and be 1½ or 2 inches thick in the stem, which rises *at once* of its permanent size and thickness in stem and walls.

The shoots of the fourth year are often full size, *i.e.*, say, starting in May, they run up 2 inches or 2½ inches thick, to 50 feet by October, the foliage not appearing till the full height is attained (for obvious reasons.)

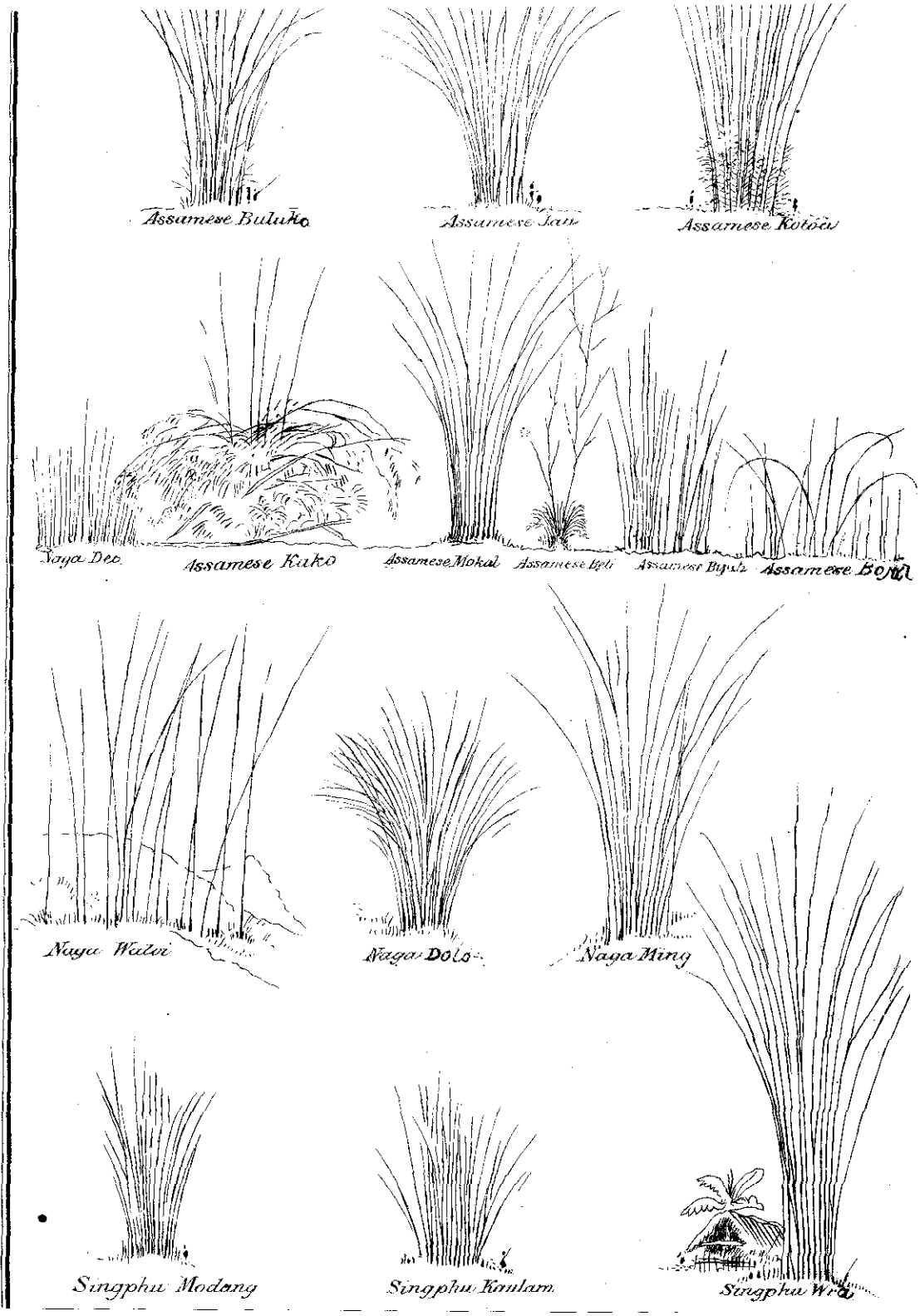
There seems hardly any difference in all the above if the shoots are first from a seed or a halm or root. The gradual annual increase in the size of the different crops of shoots or stems is what Mr. Routledge seems to have such a difficulty in realizing, and which results in his calling other people "ignorant."

Another thing I may mention as being pretty clear in this locality, *i.e.*, that, as far as I can see, fully 95 per cent. of the *clumps* of "jati" have grown from planted roots. No one can show me a clump known to have been grown from *seed.* Most of the clumps of this bamboo, found in the depths of old forest, are *in lines* on raised ridges, which show their age, besides they have other proofs.

I may here also re-state the fact that, whether bamboos are propagated naturally or artificially, it is the young one or two-year old full grown stems alone that throw up fresh stems from the rhizome—older ones are nearly useless for propagation; but these young stems are the very ones needed for pulp—old ones will not do. What is wanted for propagation is precisely what is wanted for pulp, and, if taken, propagating power is crippled. This is what I called Mr. Routledge's particular nut, no easy one to crack, and which he as yet does not even seem to have got hold of.

The cultivated kinds here are—

1*st.*—The aforesaid "Jati," 50 to 60 feet high; stem, 3-inch diameter; walls, midstem, ⅜th inch; stems live 10 to 12 years; clumps to 80.


Assamese Bulukō
Assamese Jaw
Assamese Kotōā
Naga Deo
Assamese Kuko
Assamese Mokal
Assamese Bēli
Assamese Bijulā
Assamese Bonā
Naga Walai
Naga Dolo
Naga Ming
Singphu Modang
Singphu Kimlam
Singphu Wra

2nd.—Buluka, 80 to 90 feet high; stem, 4 inch diameter; walls, say $\frac{3}{8}$th to $\frac{1}{2}$ inch; stem lives 10 to 14 years; clumps unknown.

3rd.—Kotoa (Kaint Wala), 80 to 90 feet high; stem, 3 to 4 inches; walls, $\frac{1}{4}$th to $\frac{3}{8}$th inch; stems live 8 to 10 years; clumps unknown.

Jatis are good for the hundreds of uses we see; Bulukas good for posts; and the Kotoas were always planted along the "bans gurhs," and formed a thorny impenetrable abbattis.

The semi-cultivated and wild kinds are given in the subjoined table, with their approximate size when mature:—

		Walls. At base		Joints.	
1	Kako ... 80′ × 4½″	½″ to 1″	clumped	20″ to 24″	Semi-scandent; foliage coarse and green.
2	Bijuli... 50′ × 2″	¼″ „ ½″	semi-clumped	18″ „ 20″	Straight; bluish stem.
3	Bojal ... 40′ × 1¼″	$\frac{1}{16}$ to ⅛″ „ $\frac{3}{16}$″	not clumped	10″ „ 12″	Scattered in forests; long whips; used for matting floors.
4	Mokal... 70′ × 4″	⅜″ „ 0	clumped	20″ „ 30″	
5	Beti ... 80′ × ½″	$\frac{1}{16}$″ „ ⅛″	ditto	16″ „ 20″	Climbing; branches incessantly.
6	Watoi... 70′ × 3″	¼″ „ ⅜″	not clumped	30″ „ 40″	Long joints; hills; water tubes, &c.
7	Dolo ... 50′ × 2½″	⅛″ „ ⅜″	clumped	20″ „ 25″	Matting for floors and walls.
8	Deo ... 20′ × 1¼″	⅛″ „ ¼″	semi-clumped	10″ „ 12″	Do.
9	Ming ... 90′ × 5″	½″ „ 1½″	clumped	25″ „ 30″	Water vessels among Nagas. Joints long, green stem.
10	Urd ... 90′ × 7″	⅛″ „ 2″	ditto, dense	10″ „ 15″	Water vessels among Singphus. Stem bluish, joints short.
11	Modang 40′ × 2″	¼″ „ 0	clumped	10″ „ 15″	For building.
12	Kaulam 30′ × 2″	¼″ „ 0	ditto	10″ „ 12″	To cook in.

The properties and economic uses of these are pretty well innumerable, and there can be no use in my detailing even the little I know in regard to them. Viewed solely as crops for paper pulp, I may say that the Bijuli, Bojal, Beti, Deo, Modang and Kaulam are useless, and the most likely for this purpose among the semi-planted ones, in order of the size of stems, are the Urd, Ming, Mokal, Kako; the two first are in the hills semi-planted, and rare, and the Kako is the commonest.

The Dolo and Watoi are in the hills self-sown and common, and are, I apprehend, the same as seen all down south to Aracan; the walls are thin, and hence they would give less material. Of all kinds I should say the Jati or Buluka the best, unless it turned out that the Urd extends rapidly. There are not many clumps in each Singphu village, often only one, but the

demand for it is great, and the people lazy. It is doubtless this same one that extends to China and Burma.

I have planted the Watoi, Deo, Beti, Ming, Modang, Kaulam by halms; the Bojal and Kako, though used, are too common to need planting.

I have also planted the Watoi from seed and seedlings, six inches to a foot high, retaining the grasses and jungle as shade, and simply putting four or five seedlings in a hole, and bending the grass over, as an hour's hot air and sun would kill them. About 10 per cent. lived against about 70 per cent. if put in as halms (two or three years old.)

In all matters, such as the above, I think we should, where possible, assist one another, not only by stating what little we may know, but correcting what are obvious errors; this was my aim from the first. I nowhere profess to know more than a little about bamboos here, and am very willing to learn more. I do *not* believe in controversy, but I do in quietly comparing notes. Mr. Routledge hopes he has enlightened me, and that I will feel humiliated by my ignorance. I thank him for his effort, though where the enlightenment comes in I cannot yet see.

If the Editor desires it, I will answer as many queries as I can; otherwise I have no desire to continue this subject.

S. E. PEAL.

SIBSAGAR, ASSAM,
The 14th June 1882.

[NOTE.—We are much obliged to Mr. Peal for his letter. Mr. Routledge has also been writing to us privately, and the substance of our reply is much what Mr. Peal has now given.—ED.]

Notes on some trees yielding India-Rubber, by Dr. Henry Trimen, Director, Royal Botanic Gardens, Peradeniya.

INDIA-RUBBER or CAOUTCHOUC is afforded by a considerable number of trees and shrubs, chiefly, if not entirely, members of the families *Euphorbiaceæ*, *Artocarpaceæ* and *Apocyneæ*. It is to be distinguished from guttapercha, which is a product of trees belonging to the family *Sapotaceæ*.

In its natural condition in the plant caoutchouc is a milk-like fluid, and the channels in which it occurs occupy a definite position in the structures composing the stem. It is of the highest practical importance to bear in mind that the "milk-vessels" occur wholly in the bark, externally to the cambium-layer or vitally active part of the stem where growth goes on. There are none in the wood, nor in the outer corky, papery or green layers, but only in the inner part of the bark, and either adjacent to or in its bast or liber-tissue.

The kinds of rubber-trees at present exciting interest in Ceylon are :—

(1.) *Ceara Rubber-tree.*—MANIHOT GLAZIOVII, *Müll Arg.*
(2.) *Para Rubber-tree.*—HEVEA BRASILIENSIS, *Müll. Arg.*
(3.) *Central American Rubber-tree.*—CASTILLOA ELASTICA, *Cerv.*

These three are all natives of tropical America, and are in cultivation at both Peradeniya and Henaratgoda gardens. The two former are North Brazilian Euphorbiaceous trees; the last is Artocarpaceous, and extends over a wide area from Mexico as far south as Guayaquil on the west coast of South America.

None of these species has been yet subjected to systematic cultivation out of a botanic garden, but the efforts of the Indian and Home Governments, extended over many years, have at length brought us to the eve of that long-desired result. It will, therefore, be well to make public what is known of the nature of these plants, of their surroundings in their native localities, and of the methods by which the product is obtained and prepared. Our information is unfortunately but scanty, being mainly derived from the somewhat meagre accounts of the few travellers who have had the opportunity of seeing the

trees wild, and especially of the veteran collector, Mr. R. Cross, employed by the Indian Government, by whose energy and perseverance they were brought to England.

From these extracts, and from the results of the cultivation of the trees at Peradeniya and Henaratgoda gardens, it is hoped that some answer to the numerous questions recently addressed to me by planters and others may be given, and some guidance afforded towards a successful cultivation in Ceylon.

I.—Ceara Rubber—*Manihot Glaziovii.*

1. *Locality, Soil and Climate.*—Ceara is a coast town of Brazil in Lat. 4° S., and the flat country which runs back to the hills is described by Mr. Cross as manifestly possessing "a very dry arid climate for a considerable part of the year. This is evident from the fact that mandiocca and other crops require to be irrigated. The rainy season is said to begin in November and end in May or June; torrents of rain are then reported to fall for several days in succession, after which the weather moderates for a brief space. According to some statements there are occasional years in which hardly any rain falls. This assertion concurs with the aspect presented by the country in general. The daily temperature on board the ship ranged from 82° to 85° F., but inland it is often probably 90°. The localities traversed by me nowhere seemed to be elevated more than 200 feet above the sea." At Pacatuba, about forty miles from Ceara, the actual place where the specimens were obtained, "the general forest was tolerably high, but the sparse small foliage did not afford much shade from the fierce rays of the sun. The soil was in places a sort of soft sandstone or gravel which was bound up in the most extraordinary manner. Neither grass nor weeds grew among this underwood, and there was an entire absence of ferns, mosses, and other plants." In another place somewhat further from the coast, the traveller shortly after entering the bush-like forest "came on a large tract of land covered by immense masses of grey granite, some of which might be fifty tons or more in weight. These had been broken where they lay, and were the result of a volcanic explosion. Rounded masses of the same rock also cropped out in many places.....Many good-sized rubber trees were growing in the spaces between these granite masses..... The situation was very dry, but no doubt some seedlings had sprung up, which, owing to numerous thickets of shrubs, were not perceived."

2. *Propagation and Planting.*—Mr. Cross's directions are as follows:—"Seeds are early produced, if the tree is not shaded. They should be buried in brown sand, kept pretty moist until there are indications of growth, when they may be planted out permanently. In some situations where the

ground is rough and strong they might be sown broadcast. Meantime I would suggest the formation of plantations by cuttings, which will take root as easily as a willow. These should be taken from the points of strong shoots and may be one foot in length. In planting, each cutting may be put down in the soil to a depth of six inches. If scarce, the entire shoot may be cut into pieces, each possessing a bud, all of which will grow if covered with half-an-inch or so of soil. On loose sandy soils or exhausted coffee land, plantations may be formed at little expense. Hard, dry, gravelly wastes, if found to support any kind of bush, are also suitable sites. Holes might be made in strong land with an iron jumper and a stout cutting put into each and filled with pebbles. On bare or thinly-covered portions of rock the cuttings might be laid down flat, and a little heap of stones or any kind of *debris*, about the size of a molehill, piled over each, care being taken that the extreme point of each cutting with a bud is left uncovered. I do not advocate planting in an entirely barren desert, but wherever there is any sort of stunted tree or scrub vegetation, with an occasional sprinkling from a monsoon shower, the tree is likely to prosper."

Experience of the plant in the botanic garden here has proved the general accuracy of the above remarks. There can be no doubt of the hardiness of the species, its readiness of culture, and adaptability to circumstances. It grows equally readily from seed or from cuttings; and, though a native of a tropical sea level, thrives well here in Ceylon up to at least a level of 3,000 feet, and on the most barren soils, it has succeeded equally in Calcutta and Madras, but the wet season appears to have killed it at Singapur. It would seem especially adapted for the dry and barren districts of our Eastern and Northern Provinces, or in the higher districts, but it would not be wise to risk it in localities where the temperature is liable to fall below 60° F.

Germination of Seed.—The seed coat is of remarkable thickness and very hard, and the natural process of germination occupies a long period—it is said more than a year. All that is necessary to hasten this, if desired, is to assist the seed-coat in splitting. This is best effected by holding the seed firmly, and rasping off with a file both edges at the radicular end.* It is best not to file off the actual end, as it may thus easily happen that the radicle of the embryo may be injured. After this treatment, properly performed, the young plant appears above ground in two or three weeks. The seedlings require no particular attention. They grow rapidly and may be finally planted out at distances of twenty feet. A peculiarity which they share with their close relative the mandioc

* This end is to be recognized externally by possessing at its side a flat two-lobed appendage technically known as the carbuncle.

is the possession of large tubers on the spreading roots. The trees at Peradeniya, from which seed has been distributed to Burma, India, Jamaica, &c., flowered at the age of eighteen months, and at the present time (at 2½ years) the larger ones form branching trees about 25 feet or 30 feet high, with a stem 1 foot 9 inches in circumference at a yard from the base, and a smooth, silvery, birch-like bark readily peeling off; being about half the size of those which Mr. Cross describes, and which may be assumed to have been fully grown.

3. *System of collecting the Rubber.*—I quote again from Mr. Cross's report:—"This is an operation of a very simple description. On commencing to work the collector takes with him a stout knife and a handful of twigs to serve as a broom. Arriving at a tree, any loose stones or dust are swept from the ground around the base, and some large leaves are laid down to receive the droppings of milk which trickle down. Some do not go to the trouble of sweeping the ground or laying down leaves, for which reason the milk adheres to sand, dust, decayed leaves, and other impurities. The outer surface of the bark of the trunk is pared or sliced off to a height of four or five feet. The milk then exudes and runs down in many *tortuous courses, some of it ultimately falling on the ground.* After several days the juice becomes dry and solid, and is then pulled off in strings and rolled up in balls or put into bags in loose masses. Only a thin paring should be taken off, just deep enough to reach the milk vessels; but this is not always attended to. Nearly every tree has been cut through the bark, and a slice taken off the wood. Decay then proceeds rapidly, and many of the trunks are hollow. In this condition the trees must yield far less milk, and many no doubt are broken over by the wind or wither away. Collecting is carried on during the dry season only, when rain seldom falls."

Mr. Cross says nothing as to the age of the trees so operated upon; probably the collectors treat all indiscriminately. In the sequel of his report, however, he incidentally remarks that Ceara rubber may be tapped on attaining "a diameter of four to five inches," which is the case here in Ceylon after about two years' growth. But unless there were a very large number *of trees in an extensive plantation,* this would certainly be labor thrown away. The tree, however, comes so early to maturity, as shown by the production of seed, that it is improbable that it attains any very great size. The process above described must be, if thoroughly done, almost exhaustive of the milk, but in the case of a small stem it would be a work of some care and time to so conduct it as to avoid cutting into the wood, and probably some of the methods afterwards described will be preferred. But these are practical difficulties which it may be safely assumed the ingenuity of our planters will quickly master.

II.—Para Rubber—*Hevea brasiliensis.*

1. *Locality, Soil, and Climate.*—The town of Para occupies a position near the mouth of one of the vast embouchures of the Amazon in about south latitude 1°, but the district of the same name extends over a vast forest region to the south and west, throughout which and the enormous forests of central and northern Brazil this and allied species are abundantly found. The climate has been often described and is remarkable for its uniformity of temperature, usually not exceeding 87° F. at midday, or below 74° at night. The greatest heat recorded is 95°, and the mean for the year is 81°.

The rainfall occurs principally during the months from January to June, the maximum being in April, when it reaches 15 inches. For the remaining six months of the year very little falls, but there are fine days in the wet season and occasional showers in the dry. The whole country is covered with dense moist forests, and the soil near the numerous and gigantic rivers is deep, heavy, and very fertile. During the wet season much of the low-lying country near the Amazon's mouths is flooded. In the *gapos* near Para, visited by Mr. Cross, he found a flat district only three or four feet above the highest tides and completely intersected with water-courses at low tide, filled with a soft rich mud. The forest here, in which caoutchouc-collecting was vigorously carried on, was 80 or 100 feet high, and very damp and unhealthy, the soil full of moisture and very rich and fertile. The young plants, however, were not often observed to grow actually within the reach of the tides, but it is evident that they must frequently be subject to be partially covered with water.

2. *Propagation and Planting.*—This valuable species as yet has been propagated from cuttings only. No fresh seeds were brought to this country, but to judge from dry ones in the herbarium of the British Museum, London, they are considerably larger than those of the Ceara rubber. Our largest trees at Henaratgoda, three years old, are thirty feet in height, with a slender stem scarcely branched, and about twelve inches in circumference near the base; but neither there nor in Peradeniya have they shown any symptoms of flowering.

Cuttings may be taken from the green lateral twigs as soon as they begin to harden; they strike readily in rich firm land. Mr. Cross observes that "for planting on inundated lands the period of high flood should be preferred. Cuttings of greater length would be required in this case, the lower ends of which should be sliced off in the form of a wedge. The workman could take a bundle of these, and wading into the water would plant at proper distances, but perfectly upright, taking care to push each cutting down deep enough in the soft muddy bottom, so that not more than three or four inches is above the surface

of the water. The same rule would be applicable when planting in sludge or soft marsh land. The crowns of the cuttings must not, if possible, be put under water, as the young growths springing therefrom might rot. Seeds will not be found very applicable for planting in watery places or deep mud deposits. Some would come up, but a good many would mould and decay. In the varied course of circumstances and conditions, slight changes and modifications in the methods of working will no doubt suggest themselves.....It should be planted in places where nothing else could be profitably cultivated, such as frequently inundated river margins, marsh land, and mud deposits." It would not be desirable to form a plantation in any locality where the temperature at any time falls to 60° F.

The tree when fully grown does not exceed a height of about sixty feet, and the largest trunk measured by Mr. Cross was six feet ten inches in circumference at a yard from the ground. From the upright habit of the tree it will not be necessary to plant at any great distance apart.

Over 500 plants have been sent from Ceylon to Burma and some to the Madras Presidency. An attempt to grow the tree in Assam failed.

3. *Collection of the Rubber.*—Several accounts have been given of this, the fullest and most recent being that of Mr. Cross, who saw in practice the methods employed in the neighbourhood of Para. His description is as follows :—

"The collectors begin to work immediately at daybreak, or as soon as they can see to move about among the trees. They say the milk flows more freely and in greater quantity at early morn. I do not attach much importance to this statement, but I have recorded it. Another and more probable reason is, that as rain often falls about two or three o'clock in the afternoon, the tapping must be done early, as in the event of a shower the milk would be spattered about and lost. The collector, first of all, at the beginning of the dry season, goes round and lays down at the base of each tree a certain number of small cups of burnt clay. At the lesser trees only three or four are put, but at the larger ones from eight to twelve are deposited. The footpaths leading from tree to tree are likewise cleared of sapling growths, and the bridges over the *gapos* (natural ditches) formed at each place by the trunk of a tree are, where necessary, replaced. On proceeding to his work the collector takes with him a small axe for tapping, and a wicker-basket containing a good-sized ball of well-wrought clay. He usually has likewise a bag for the waste droppings of rubber, and for what may adhere to the bottoms of the cups. These promiscuous gatherings are termed *sernamby* and form the "negrohead" of the English market. The cups, as already stated, are of burnt clay, and are sometimes round, but more frequently flat or slightly concave on one side, so as to stick easily, when with a small

portion of clay they are pressed against the trunk of the tree. The contents of fifteen cups make one English imperial pint. Arriving at a tree the collector takes the axe in his right hand, and striking in an upward direction as high as he can reach, makes a deep upward sloping cut across the trunk, which always goes through the bark and penetrates an inch or more into the wood. The cut is an inch in breadth. Frequently a small portion of bark breaks off from the upper side, and occasionally a thin splinter of wood is also raised. Quickly stooping down he takes a cup, and pasting on a small quantity of clay on the flat side, presses it to the trunk close beneath the cut. By this time the milk, which is of dazzling whiteness, is beginning to exude, so that if requisite he so smooths the clay that it may trickle direct into the cup. At a distance of four or five inches, but at the same height, another cup is luted on; and so the process is continued until a row of cups encircle the tree at a height of about six feet from the ground. Tree after tree is treated in like manner, until the tapping required for the day is finished. This work should be concluded by nine or ten o'clock in the morning, because the milk continues to exude slowly from the cuts for three hours or perhaps longer. I may state that there is a great difference among collectors in the performance of these duties. Some take care to get good clay previously and incorporate it well, so that a very small portion is needed to lute the cups to the trunks; they also work with neatness and intelligence, and invariably collect a good quantity of milk. Others, again, do not take the trouble to prepare clay beforehand, but merely scrape up a handful when they require it at the side of a *gapo*, which is often of little consistence, so that a large quantity is required to fasten the cups. This class of collectors have often many fragments of clay or other impurities in their milk, the result of not following a proper method of working. The quantity of milk that flows from each cut varies, but if the tree is large and has not been much tapped, the majority of the cups will be more than half full, and occasionally a few may be filled to the brim. But if the tree is much gnarled from tapping, whether it grows in the rich sludge of the *gapo* or dry land, many of the cups will be found to contain only about a tablespoonful of milk, and sometimes hardly that. On the following morning the operation is performed in the same way, only that the cuts or gashes beneath which the cups are placed are made from six to eight inches lower down the trunks than those of the previous day. Thus each day brings the cups gradually lower until the ground is reached. The collector then begins as high as he can reach, and descends as before, taking care, however, to make his cuts in separate places from those previously made. If the yield of milk from a tree is great, two rows of cups are put on at

once, the one as high as can be reached, and the other at the surface of the ground, and in the course of working, the upper row descending daily six or eight inches, while the lower one ascends the same distance, both rows in a few days come *together*. When the produce of milk diminishes in long wrought trees, two or three cups are put on various parts of the trunk, where the bark is thickest. Although many of the trees of this class are large, the quantity of milk obtained is surprisingly little. This state of things is not the result of overtapping, as some have stated. Indeed, I do not believe it is possible to overtap a tree if in the proportion the wood is not left bare or injured. But at every stroke the collector's axe enters the wood, and the energies of the tree are required in forming new layers to cover those numerous wounds. The best milk-yielding tree I examined had the marks of twelve rows of cups which had already been put on this season. The rows were only six inches apart, and in each row there were six cups, so that the total number of wood cuts within the space of three months amounted to seventy-two. It grew close to a *gapô* only eight inches above high-tide mark, and being a vigorous tree the cups were usually well filled, but with two years or so of *such treatment the tree* would probably be permanently injured. It has been supposed that the quality of the milk is better in the dry season than during the rains. Such is the case with some vegetable products, but as regards India-rubber there ought not, I think, to be any appreciable difference. In the rainy season the milk probably contains a greater proportion of water, but, on the other hand, I am of opinion that then a larger quantity of milk flows from the tree. No doubt the dry season is the most suitable for caoutchouc collecting, although wherever a plantation is formed with preparing house convenient tapping may certainly be always carried on when the weather is fine.....There are two other methods adopted in tapping which are chiefly confined to the Upper Amazon and tributaries. Both are exactly on the same principle, the materials used being only a little different. The loose outside bark of the tree is cleaned off to a height of about three feet. Beneath, a gutter or raised border of clay is pasted or luted to the trunk, *enclosing one-half of the entire* circumference. Cuts are thickly made in the bark above this, from which the milk flows down to the gutter, whence it is conveyed to fall into a calabash conveniently placed. The other mode is by winding round the trunk the stout flexible stem of a climber, and claying it round securely so that no milk may escape between the trunk and the climber. These plans are not extensively adopted, and can only be successfully put in practice where the trees have not been previously tapped. There is always a great deal of "negro-head," the result of the distance the milk has to run, and to the large quantity of clay employed in the process.

"*Collection of the Milk.*—Going from tree to tree at a sort of running pace, the collector empties the contents of the cups into a large calabash, which he carries in his hand. As he pours the milk out of each cup he draws his thumb or fore-finger over the bottom to clean out some which otherwise would adhere. Indeed a small quantity does remain, which is afterwards pulled off and classed as *sernamby*. The cups on being emptied are laid in a little heap at the base of each tree, to be ready for the following morning. The trees occur at various distances from 10 to 100 yards apart, and as I travelled over the intricate net-work of muddy footpaths, I continually felt perplexed and surprised that the natives have not yet seen the advantages that would be derived by forming plantations, whereby more than twice the quantity of caoutchouc might be collected in one-fourth the time, and at far less cost and labor."

The trees are tapped if they have a circumference of eighteen or twenty-four inches, and the rough process above described is carried on for many years, until the constant and extensive injury to the young wood causes their death, for some years previous to which event they almost cease to yield milk and are practically abandoned.

It will be advisable, in order to avoid this injury, to employ an instrument for cutting so shaped and guarded that it shall not be able to penetrate beneath the inner bark. With this precaution it will probably be found unnecessary to rest the trees as has been recommended by some; but actual experience alone can decide on the method of tapping which will secure the greatest yield with the least damage to the tree's general vitality.

III.—CENTRAL AMERICAN RUBBER-TREE—*Castilloa elastica.*

1. *Locality, Soil and Climate.*—The very extensive geographical range of this tree shows it capable of existing under considerably varied climatal conditions. The forests in which it grows are usually at or near sea-level, but it has been observed at an elevation of 1,500 feet on the Pacific coast. The soil varies, but the plant avoids marshy or boggy land, appearing to prefer warm, deep loam or sandy clay, and especially affecting the margins of small running streams where it grows in little groups. A dry or a rainy climate seems equally suitable, but a high and equable temperature, which does not sink below 60° F. at any time, is essential.

2. *Propagation and Growth.*—This is a very much larger tree than those above described, being, when fully grown, of the imposing height of 160 to 180 feet, with a stem of 12 to 15 feet in circumference. It grows very rapidly. At Henaratgoda at two years of age it was 23 feet in height. The bark is thick, and the wood soft and readily decaying. We received but a few plants of this species in Ceylon, and have had little

experience in its management. No flowers have been yet produced, and Dr. Thwaites did not find cuttings of the ordinary kind to succeed well. We are now however endeavouring to propagate at Peradeniya by various other methods.

Mr. Cross has the following remarks:—"Trees in good situations will produce seeds early, but these will require to be planted without delay as drying destroys their vitality." The tree is stated to flower in January, and the fruit to be ripe in April. "Stout branches, cut into pieces, each possessing a bud and covered lightly with soil, will generally be found to grow. Strong cuttings, a foot in length and furnished with buds, when planted in the usual way, will become strong plants sooner. However, the propagation of this tree will not be found so easy as the Ceara rubber. In the planting out of young plants, the petiole or leaf-stalk of the lowest or oldest leaf should be buried in the soil. By following this simple rule the plant commences to grow at once, its growth is vigorous, and the trunk symmetrical. But if at the period of planting there is much bare stem above ground, then growth is usually slow, the plant remains 'leggy' for some time afterwards, and never makes a good tree." The plant has a curious habit of dropping its young branches, which disarticulate by a regular joint, like deciduous leaves, and leave a clean scar on the surface of the stem. From what has been said above as to its native sites, it would seem that our south-western coast would present many favorable localities for this valuable tree.

3. *Collection of the Rubber.*—Milk is abundant and flows readily, but it is of a somewhat more watery consistence than that of the Para rubber. In consequence of the large size of the trees it is the practice of the collectors in Panama and other parts to cut them down. A groove or ring is first cut round the base of the trunk and the milk received into large leaves. "The tree is then felled, and rings or channels are cut out around the prostrate trunk at about twelve or fourteen inches apart," and the rubber allowed to run into leaves or vessels. In Nicaragua the trees are tapped with sharp axes in various ways, and the trees so much injured that the process is performed at intervals of three years. The milk is received into iron pails. It does not appear that this species is tapped until it has a diameter of sixteen or eighteen inches, which Mr. Cross thinks might be attained in six years.

In conclusion, a few words may be said about the preparation required to fit caoutchouc for the market. It is clear that mere exposure to the air is sufficient in some cases to effect the coagulation of the milk into a solid mass. This is all the preparation apparently that the Ceara rubber receives, which comes into the market in balls consisting of the rolled up strings pulled off the tree. But it seems that a decomposition is liable to occur in the milk if exposed in any quantity, and

it is usually desirable to reduce it to a solid mass as quickly as possible. For this purpose the cautious application of dry heat is the best; the best Para rubber is prepared by being poured over a flat paddle-shaped mould, which is held in the thick hot smoke from burning wood and palm-nuts till it solidifies, then slit down one side, the mould taken out and the "biscuit" hung up to dry. In several parts of Central America coalescence is effected by the addition to the milk of the juice of certain plants (especially of *Calonyction speciosum*, which is a common convolvulus here in Ceylon). This causes the separation of the caoutchouc, which floats in the liquid like a mass of soft cheese, and has to be pressed and rolled to get rid of the fluid still remaining in its substance.

Probably carefully conducted evaporation in shallow pans by *artificially regulated heat would be found an effective method.*

The purity of the prepared rubber being a matter of first importance, all pieces of bark and earth should be removed by passing the milk through sieves. Small pieces or thin sheets of caoutchouc are preferred to large masses in the market from the facility of estimating the purity of the article.

Absolute dryness of the rubber is also a point requiring the greatest attention, and may require hydraulic pressure for its thorough attainment.

As much as 129,163 cwts. of caoutchouc were imported into England in 1874, of which 70,866 cwts. was American and obtained from the plants here under consideration. The value of this latter was £1,007,413. The demand for the best sorts is constantly increasing. On the relative market values of the various kinds of India-rubber reference may be made to the excellent "Report on the Caoutchouc of Commerce" by Mr. Collins, and printed for the Indian Government in 1872, to which I am indebted for some of the above information, and to a paper by C. R. Markham in the "Journal of the Society of Arts" for April 7th, 1876.—(*Mysore Gazette.*)

Notes for a Manual of Sylviculture.

THE following pages are extracted from the rough draft, as it now stands, of BOOK II of the MANUAL OF INDIAN SYLVICULTURE, which is in course of preparation. They are published here, as they deal with subjects which ought evidently to be discussed as widely as possible before the Manual takes its final shape.

Forestry in India is an art of very recent growth, while in the United Kingdom there is not only no uniform set of technical terms in general use, but, moreover, owing to the fact that forest management on a large scale has, for obvious reasons, never yet formed an essential part of the State economy, several important ideas, which to the continental forester are every-day commonplaces, have not received their expression except in seldom-used clumsy periphrases. In drawing up our technical vocabulary we have hence considered ourselves completely unfettered by present practice, save in so far

that we have felt ourselves bound to accept current words that are logical equivalents of the ideas for which they stand. For instance, there was no reason to exclude the terms *stock, crop, stool, copse*, &c. Then, again, the expressions *high forest, regeneration, rotation*, and several others, which, although foreign to purely English ears, are nevertheless recognised in India, have been retained without any qualification. Whereas, instead of the current term *coppice-shoot*, we have adopted *stool-shoot*, which the shoot meant really is. A copse may, as we all know, be composed wholly or partly of root-suckers, and the former word would also logically include these shoots from the roots. To give one more instance: Instead of the expression *water-shoots*, which at the best is extremely unscientific and misleading, we have coined the word *epicorm* (Επι, *upon*, and Κορμος *a stem*).

The most crucial test of a good *lingua technica* is that it should be at once intelligible, and at the same time in sympathy with the spirit of the vernacular to which it belongs. The moment for submitting our technology to the criticism of the public in general, and of foresters, British as well as Indian, in particular, would have arrived when the entire Manual was in print. But in the present case we are met at the very outset with this difficulty, that year after year a certain number of Indian forest officers and subordinates are trained at the Central Forest School at Dehra Dun, and for their course of instruction we must have a complete set of technical terms that have received the sanction of foresters working in every part of the world where English is spoken. To wait until the publication of the Manual would be to teach in the meantime a vocabulary, which must soon after be unlearnt.

The technical terms, with their definitions, which are now given, are only such as occur in Chapter II of the Manual which immediately follows. The rest will be published in some future number of the INDIAN FORESTER.

The Chapter of the Manual just alluded to is the very first attempt hitherto made to describe in detail, although in as brief a manner as possible, the *struggle for existence* between the various plants composing a forest crop. Why certain species should predominate at a given age, why these or others should maintain themselves in the crop, while the rest are gradually driven out or left completely in the minority later on, is the first question which the forester ought to be able to answer, especially in India, where sometimes more than 100 different species of trees and shrubs grow together within the limits of a single square mile. And it is on account of this very variety of species, and the great diversity of the effective factors of soil and climate that the task of answering it satisfactorily is extremely difficult, and certainly impossible for a single

individual, without the active and sympathetic co-operation of foresters in the several provinces and districts of India.

The "INDIAN FORESTER" is soon to become a monthly journal, and it is earnestly hoped that its more frequent issue will induce its readers to criticise freely the following extract from the Manual of Indian Sylviculture, and offer us the benefit of their special experiences. The Manual is intended for all the territories under the jurisdiction of the Viceroy of India, and illustrations of general principles from districts outside the range of our observation are invited, and will supply many unavoidable and regrettable omissions.

BOOK II.—INDIAN SYLVICULTURE.

PART I.—GENERAL.

CHAPTER I.—*Preliminary Definitions.*

A TREE is any woody plant branching from a certain height above the ground, and capable of attaining a minimum height of 25 feet. The term "tree" includes arborescent palms and bamboos.

Trees may be classed as follows :—

(*i.*) LARGE trees, those which can attain a height of over 80 feet, *e.g.* teak, sal, deodar, &c.

(*ii.*) MIDDLE-SIZED trees, those which attain a height of between 50 and 80 feet, *e.g.* sissoo, *Anogeissus latifolia*, babul, *Quercus semecarpifolia*, *Quercus incana*, toon, &c.

(*iii.*) SMALL trees, those which attain a height of from 25 to 50 feet, *e.g. Ougeinia dalbergioides*, khair, *Anogeissus pendula*, *Butea frondosa*, &c.

A SHRUB is a woody plant incapable of attaining a greater height than 25 feet, and which branches at or near the base, *e.g.* the custard apple, *Bauhinia racemosa*, citron, *Randia dumetorum*, *Murraya Kœnigii*, the tea plant, *Mimosa rubicaulis*, &c.

A *shrub that assumes the habit of a tree is said to be* ARBORESCENT, *e.g.*, *Bauhinia racemosa*, *Murraya Kœnigii*, &c.

A woody plant, which never rises very much above the ground, is called an UNDERSHRUB, *e.g. Justicia Adhatoda*, the paper daphne, *Desmodium gangeticum*, &c.

The term BUSH includes undershrubs and every degraded condition of shrubs and trees, in which the plants consist of numerous low spreading branches, such as the various species of *Zizyphus*, oaks, &c., when kept down by fires, grazing, constant lopping, &c.

The word SCRUB denotes a collection of bushes, shrubs, and dwarfed trees.

The collective name of BRUSHWOOD is given to all inferior shrubs, undershrubs, and other bush-like growth, such as

Mimosa rubicaulis, the *Indigoferas*, *Blumea*, *Buddleia*, degraded forms of *Zizyphus*, &c.

The term HERBAGE includes all the growth in a forest which is not woody.

Any plant which cannot rise to any height above the ground, except by attaching itself, as it rises, to some extraneous support, such as a tree, shrub, post, &c., is called a CLIMBER, *e.g.*, *Bauhinia Vahlii*, *Spatholobus Roxburghii*, *Millettia auriculata*, *Celastrus paniculata*, *Butea superba*, the cane palms, &c.

The length of the stem of a tree under its branches is called its BOLE, and the mass of branches with their branchlets and leaves, *i.e.*, the whole of the tree above the bole, is called its crown.

The aerial stems of bamboos are called CULMS, the underground portion being the RHIZOME.

The stem of a palm tree is termed a CAUDEX (plural caudices.)

That portion of the stem which is left in the ground after a tree, whatever its age, has been felled, is called a STOOL. In popular language the word STUMP, besides including stools, denotes the whole portion of the bole of the tree that has been cut or broken off high above the ground.

EPICORMS are the twigs and the branchlets that develop on the boles of trees, when these are suddenly exposed to light.

Dicotyledonous trees, as distinguished from the Conifers, which bear needles, may be termed BROAD-LEAVED trees. (This term has already been employed in anticipation in Part I, Chapter II, Section iii.)

HARD-WOODED trees, or simply the HARDWOODS, comprise in a general manner all trees with tough and heavy wood, as, for example, sal, teak, the *Terminalias*, &c. Similarly the terms SOFT-WOODED trees or the SOFTWOODS include all trees, the wood of which is more or less soft or spongy, such as *Bombax malabaricum*, the *Sterculias*, the horse radish tree, &c.

A forest is said to be PURE, when it is composed entirely, or almost entirely, of a single species, the other species, when any exists, being found only as brushwood or inferior undergrowth; such are the numerous large stretches of babul, of tamarisk, and of *Pinus longifolia*.

When two or more species in varying proportions compose the growth, the forest is said to be MIXED.

A GREGARIOUS tree is one which has a tendency to form more or less extended masses of pure forest, as, for example, sal, sissoo, *Pinus longifolia*, &c. Such trees may also be called EXCLUSIVE; and, as distinguished from them, those trees which only grow in mixed forest, may be termed SOCIAL, such as teak, *Dalbergia latifolia*, *Adina cordifolia*, &c.

EVERGREEN trees are those, the leaves of which persist for at least one year, and do not all fall at the same time ; while those, the leaves of which persist for a shorter time, and all fall within a few days, are termed DECIDUOUS. Evergreen trees are, therefore, never leafless, *e.g.* deodar, the pines and firs, mango, &c., whereas deciduous trees may either be leafless during a part of the year, as teak, *Terminalia tomentosa, Adina cordifolia,* babul, or be never quite bare owing to the new leaves coming out while the old ones are being shed, as sal, *Eugenias, Schleichera trijuga,* &c., generally, and sissoo, *Hardwickia binata,* &c., frequently.

The term CANOPIED FOREST denotes a collection of trees of any age, the crowns of which meet.

The LEAF-CANOPY is the continuous mass of foliage formed by the crowns of the trees of a canopied forest. It is said to be COMPLETE, when the branches interlace and form an unbroken mass of foliage. It is said to be OPEN, when the crowns, although they meet, do not touch each other at every point. In the former case, only diffused light can enter the forest below the mass of crowns, while in the latter direct light will also pass through in patches. The leaf-canopy is said to be INTERRUPTED, when there are intervals between the crowns of the trees.

By STOCK or CROP is meant the entire forest growth standing on any given area, and it is said to be COMPLETE for any age, when it is the maximum quantity which the soil can bear at that age.

To STOCK or CROP any piece of ground means to cover it with forest growth. The terms to RESTOCK or RECROP are used when the area in question has once been under forest.

The DENSITY of a crop signifies the degree of closeness of the growth constituting it.

A REGULAR crop is one in which the leaf-canopy, besides being complete, is formed by trees of nearly the same age and size. An IRREGULAR crop, on the other hand, is one in which the leaf-canopy may or may not be complete, but is formed by trees of very various ages and sizes.

A REGULAR FOREST is one which consists of conveniently distributed regular crops, representing every stage of growth from the nascent plant to the tree fit for felling, and covering more or less equal areas or areas of more or less equal productive power. In the contrary case the forest is said to be IRREGULAR, *e.g.*, all our present natural forests.

A shoot springing up from a stool is termed a STOOL-SHOOT.

A young plant, which results directly from the germination of a seed, until it begins to lose its lower branches, is called a SEEDLING.

The term seedling *is also conveniently prefixed as a qualifying word to the words* sapling, pole *and* tree *(for the meaning of*

which terms see below) to denote that the sapling, pole *or* tree *in question has sprung up directly from seed.*

By a further limitation the expression seedling-shoot *is synonymous with a stool-shoot springing up from a seedling cut back either artificially, or by fire, frost, or any other natural cause.*

A ROOT SUCKER or more simply SUCKER, is an aerial shoot given out from a root.

From the time any woody plant begins to lose its lower branches until it has attained a girth of 12 inches it is called a SAPLING.

Thenceforward, until it reaches its full length of bole, it is designated by the general term of POLE. For the sake of further subdivision, poles are termed LOW or HIGH, according as they are under or over two feet in girth.

The pole stage of growth being passed, the plant becomes a FORMED TREE. When there is no risk of ambiguity the word TREE without any qualification may be used in this sense.

When a sapling, pole, or tree is the immediate result of growth from the stool, the qualifying expression ON THE STOOL or ON STOOLS will be affixed, or the word STOOL prefixed to those terms.

A collection of shoots springing up from one and the same stool is called a CLUMP. The term clump is also applied to the collection of culms composing an individual bamboo plant.

When a sapling, pole or tree has grown up from suckers, the term SUCKER will be prefixed to those words.

A HIGH FOREST is a forest composed entirely of seedling trees.

A COPSE is a forest that is composed chiefly of stool-shoots and suckers.

A tree is said to COPPICE well when it produces itself freely from the stool. The verb TO COPPICE is also used in an active sense, and means to fell a crop in order to obtain a *regrowth* from the stools of the trees felled.

To CUT BACK means to fell any plant, younger than a formed tree, by its base, and this with the object of obtaining, if possible, a fresh growth from it.

To POLL or TOP OFF a plant signifies to remove its crown.

A POLLARD is a tree that has been polled or topped off.

TO EXPLOIT a forest or crop means to fell it in accordance with the principles of sylviculture. The noun EXPLOITATION corresponds to the verb just defined.

TO REGENERATE a forest signifies to produce a new crop in place of the old exploited one; and the REGENERATION of a forest is accordingly synonymous with the substitution of the one crop for the other.

The regeneration of a forest or crop is said to be NATURAL

or ARTIFICIAL, according as the new crop is the immediate consequence of the exploitation of the old one, or is due exclusively to means extraneous to, and independent of, the old crop and its exploitation.

The name REGROWTH is specially given to the new crop obtained by coppice regeneration (*vide supra under definition of to coppice.*)

A ROTATION is the number of years fixed for the successive and complete regeneration of an entire forest.

Regeneration, broadly speaking, may be obtained (i), either by seed; or (ii), by stool-shoot, suckers, &c. When the former is the case, we have the HIGH FOREST REGIME; and when the new crop consists of stool-shoots, suckers or culms, we have the COPPICE REGIME. The régime hence depends on the manner in which regeneration is obtained.

With the same régime, different methods of culture may be adopted, each constituting a separate METHOD OF TREATMENT.

The various species composing a mixed forest may be distinguished into three several classes—PRINCIPAL, AUXILIARY and ACCESSORY.

The PRINCIPAL species is that (there may be one or more) which, from the superior value of the produce it yields, and the general suitability of the prevailing conditions for its favourable growth, necessarily determines and regulates the rotation, régime, and method of treatment to be adopted in a forest.

Of the remaining valuable species well distributed throughout the forest, or capable of being generally introduced there, those are qualified as AUXILIARY, which, possessing different requirements from the principal species, utilize space both in the soil and in the leaf-canopy not occupied by the latter, and in doing so, promote and improve their growth.

All other species, which are neither principal nor auxiliary, are termed ACCESSORY. These are either too slightly distributed, or do not attain a sufficiently large size in the forest in question, or yield produce of too little value to influence in any way the working and treatment of the forest.

Thus in teak forest, teak would be the principal species; *Dalbergia latifolia, Terminalia tomentosa, Schleichera trijuga, Pterocarpus Marsupium, Anogeissus latifolia, &c.*, the auxiliary species; and *Sterculia urens, Odina Wodier, Cochlospermum Gossypium, &c.*, the accessory species. In special cases, however, in the present state of the market, *Dalbergia latifolia* and some other trees classed as auxiliary (e.g., *Hardwickia binata, Pterocarpus Marsupium, &c.*), provided they are abundant enough, may become principal species in company with the teak. Again in sal forest, sal would be the principal species; *Schleichera trijuga, Lagerstræmia parviflora,*

Adina cordifolia, *&c.*, the auxiliary species; and the *Tetrantheras*, *Phœbe lanceolata*, *Buchanania latifolia*, *Semecarpus Anacardium*, *Mallotus philippinensis*, *&c.*, the accessory species. Lastly, in deodar forest, deodar would of course be the principal species; the spruce and silver firs, *Pinus excelsa*, *&c.*, the auxiliary species; and species of *Rosaceæ*, *Cornaceæ*, *Celastrineæ*, maples, hollys, &c., would compose the accessory class.

A COUPE is any area in which a felling has been or is to be made, and the produce obtained from the felling is collectively called the FALL.

To CLEAN FELL a coupe means to remove the entire crop standing on that coupe, the corresponding operation being termed a CLEAN FELLING.

When a coupe is not clean felled, the trees left standing are collectively termed the RESERVE. When the reserve is spared long enough for a young forest crop to establish itself under it, this lower crop is termed the UNDERWOOD. As distinguished from underwood the term UNDERGROWTH is generic in its signification, and includes, besides the underwood, all other brushwood, bushes, herbage, &c., standing under any loftier crop of trees.

The seedlings which make their appearance before the mature trees in a coupe are felled will be termed the ADVANCE GROWTH.

A BLANK is any area inside a forest which is bare of trees.

A GLADE is a portion of forest in which the trees are scattered.

The term WINDFALL is applied to trees broken or uprooted by any cause whatsoever, generally by the wind.

HARDY plants are those which resist exposure to frost and drought at all ages, *e.g.* *Zizyphus*, khair, sissoo, &c. Those which require to be sheltered against frost or drought during their early years are termed DELICATE PLANTS as, for example, teak, deodar, *Terminalia tomentosa*, &c.

Plants which maintain themselves alive under more or less dense shade are said to be SHADE-BEARING, *e.g.*, deodar, sal, silver fir, *Mesua ferrea*, *Hardwickia binata*, *Dendrocalamus strictus*, *&c.*; while those which can only live in more or less direct sunlight are said to be SHADE-AVOIDING, *e.g.*, teak, *Pinus longifolia*, *Pinus excelsa*, &c.

Shade-bearing plants may be *hardy*, like *Mesua ferrea*, *Hardwickia binata*, *Dendrocalamus strictus*, *Acacia Catechu*, &c., or they may be *delicate*, like the silver fir, deodar, toon, *Terminalia tomentosa*, &c.

A plant is said to be growing UNDER COVER, as opposed to its growing OUT IN THE OPEN, when it is vertically under the crown of another plant. Accordingly the COVER of a tree means the action exercised by its crown within the space

below included in its vertical projection. Hence *shade* is not synonymous with *cover*, since the latter is stationary, while the former moves with the sun.

DORMANT BUDS are those which remain concealed under the bark, and burst forth into leaf only under stimulating external conditions, especially where, through natural or artificial operations, there is an absence or insufficiency of other buds to carry off the developmental energy of the plant or organ.

CHAPTER II.—*Struggle for existence between the individual plants of a forest crop.*

Of the plants produced in a forest only a comparatively small number can live the full term of their individual longevity. As they develop, besides extending vertically upwards into the air, and downwards into the soil, they spread *out laterally against each other. But since their lateral* extension, both in space and in the soil, is obviously limited to the superficies which the forest actually covers, each one naturally struggles to push out its neighbour. In this struggle for existence the stronger and more vivacious plants crowd against or overtop the rest, which hence gradually succumb and disappear one after another at various ages. In other words *the fittest survive*. The conditions that determine this survival of the fittest are extremely complicated, and may best be studied by examining four separate cases which are practically exhaustive.

These four cases, beginning with the simplest, are—

(i.) That of a crop composed of plants of the same age and all belonging to one and the same species.

(ii.) That of a crop composed of a single species, but in which the plants are of all ages, from the seedling just germinating to the tree that has attained its full term of longevity.

(iii.) That of a crop composed of plants of the same age, but belonging to more than a single species.

(iv.) That of a crop composed of trees of all ages and belonging to more than one species.

SECTION I.—FIRST CASE.—*Pure crop composed of individuals of one and the same age.*

In this case, as long as the plants are small and stand spart, they do not impede the free development of each other; the struggle for existence begins only when their crowns meet and close over the ground.

All plants require a certain amount of light, less or greater according to their species, in order not only to grow but even simply to live. Hence those individuals, which do not receive sufficient light, either because they are overtopped or because they are too close pressed laterally, must sooner or later die

and disappear. The conditions which, in the case under consideration, enable the survivors to gain the victory are, therefore—

I. RELATIVE INNATE VIGOUR.—Why one plant should possess more innate vigour than another cannot always be explained; we can only recognize the fact when we observe it. This relative superiority or inferiority, as the case may be, manifests itself as soon as the plants, having left their seed-cap to shoot up into the air, begin to assimilate for themselves. In a seed bed, containing one and the same soil, and with every other condition exactly identical, some plants will be found to be naturally larger, more vigorous, and more hardy than others. Again, stool-shoots are much larger and stronger than, and easily suppress seedlings of their own age.

II. GREATER SUITABILITY OF SOIL AND SUBSOIL.—The influence of soil and subsoil is of only slight importance in the case under consideration, as long as two neighbouring plants are quite young and small; since it is seldom, except in extremely rocky, stony, or uneven ground, that these elements of growth vary from point to point to a sufficient extent to influence differently their development. But when the plants are large enough to stand some distance apart while still touching crowns, this condition may exercise a very marked differential effect on their growth.

III. DEATH, DISEASE, UNHEALTHY STATE, OR RETARDATION OF GROWTH BROUGHT ON BY CAUSES EXTRANEOUS TO THE FOREST, *viz*:—

(a.) Attacks of insects and other animals.—Some insects, especially the lignivorous kinds, attack chiefly or solely the weaker plants; while others, like certain caterpillars, and particularly the various silkworms and the larvæ of sawflies, and of certain *Coleoptera*, attack all indifferently, and even rather affect plants possessing abundant well developed juicy foliage. Again, the lac insect prefers the strong juicy shoots of vigorous plants to the more or less dry, more or less hide-bound twigs of less vigorous individuals. Moreover, cattle, goats, and other herbivorous animals, while they do not spare weakly plants, still fall more greedily on strong ones with abundant, well-developed, juicy twigs and foliage. Lastly, man himself will, as a rule, fell and remove only what suits his purpose, the strong as well as the weak plant. Hence it is not invariably, nor generally, the weaker plants that succumb to this cause.

(b.) Attacks of parasitic and epiphytic plants.—Injurious parasitic plants will, as a rule, attack only the weaker individuals; while epiphytic plants make no distinction between weak and strong.

(c.) Damage caused by climatic influences—frost, drought, sunstroke, hail, rain, wind, snow, lightning, &c.—Other con-

ditions being the same, all plants will suffer equally from these causes, especially from frost, drought and hail. But the weaker and lower plant may be sheltered by its more vigorous and taller neighbour, which, as often as not, will be so injured as to allow the former to get ahead of it. The wind might uproot or break off an important limb of the strong tree; under the weight of superincumbent snow one or more large boughs might snap off; lightning might select the tallest or largest tree, and so on; and thus allow the weaker to conquer in the struggle for existence.

(*d.*) *Damage caused by fire.*—Here of course the larger and more vigorous the plant is, the greater will its power of resistance be; but, as often happens, the large tree might be so injured as to throw it hopelessly back in the race of life. In the case of conifers and species which coppice badly, the smaller plants will stand comparatively little chance of recovery.

(*e.*) *Floods.*—Here also it is natural to expect that the resistance offered by the strong tree will be greatest; but a violent rush of water might lay down or strain and injure the roots of the large and vigorous tree, while its weaker neighbour, owing to the very fact that it opposes slighter resistance, might be bent down for the moment only, to rise up again as soon as the flood has passed, and shoot up ahead of it.

(*f.*) *Injuries caused by felling, conversion, and export operations.*—The smaller and weaker plants will, of course, on the whole, suffer most, but the fall of a large tree is more likely to break and throw back for ever plants with a rigid, more or less unyielding stem than those which simply get bent down for the moment until the fallen tree is removed.

(*g.*) *Climbers.*—Climbers kill or at least unfit trees for the struggle for existence in four different ways—

(i.) They may strangle the stems of their supports, narrowing year after year the channel through which alone the sap, pumped up by the roots, can ascend.

(ii.) They also bend down these stems by their weight.

(iii.) When they get up into the crowns of their supports, they invade and overspread these crowns, which cannot, therefore, bear their full quantum of foliage, and are also thereby impeded both in their lateral and upward development, especially in the latter.

(iv.) They distort the boles of their supports, and thus necessitate the removal of these latter by the forester.

IV. DENSITY OF THE LEAF-CANOPY.—It is obvious that the plants, which have free space round and over them, will keep on growing and survive, while others, taller and stronger than they, but less so than their immediate neighbours, succumb under this cause.

Every species whatsoever, whether shade-bearing or shade-avoiding, can form a denser leaf-canopy when young than at a later age, and their need for light increases directly with age. In a complete crop the density of the leaf-canopy remains at its maximum up to the time when the trees have nearly attained their full length of bole. Thenceforth the leaf-canopy becomes gradually sparer, until, at a very advanced age, varying with the species concerned, the individual trees stand completely isolated.

The more favorable the soil and locality is, the closer together can the trees stand at any age; and, in general, the presence of sufficient moisture in the soil and in the atmosphere, combined with the requisite temperature, increases the ability of a species to form a dense leaf-canopy at all stages of growth, by encouraging the development of foliage, and hence the spread, depth, and thickness of the crowns.

All species form a denser leaf-canopy the longer the period of vegetation in each year is, for when this period is short, the action of light ought, in order to produce the same effect, to be more energetic in proportion, and the trees must, accordingly, stand further apart.

Lastly, the greater the intensity of sunlight at any place is, the more shade-bearing does a given species become; and conversely, the less intense the light, as, for instance, on northern aspects, in mist and fog-clad regions, under generally clouded skies, &c., the further apart will the trees grow, and the more will they object to being overtopped. Moreover at high elevations diffused light has more effect on vegetation than at lower altitudes; hence the higher a place is above the sea-level, the denser will be the growth of any given species.

If the species composing the crop is shade-bearing, like the deodar, silver fir, *Quercus incana*, *Terminalia tomentosa*, *&c.*, or one which at all ages interlaces branches, like the khair, species of *Zizyphus*, *Anogeissus pendula*, *A. latifolia*, &c., the struggle for existence is a long and severe one. On the other hand, when the constituent species is like the *Pinus longifolia*, or the *Hardwickia binata*, the first shade-avoiding from its earliest years, and both abhorring the interlacing of branches, the struggle is a brief one, and the weaker and overtopped plants are soon thrown out of the race.

Examples of the First Case.

Natural instances of the First Case may be found in the tamarisk forests of Sindh and in some of the babul forests of the same province; also in bamboo forests, the constituent species of which flowers gregariously. Another striking instance is offered by copses of a single species that are clean-felled, in which, practically, all the stool-shoots spring up the very first season following the exploitation. This of course

includes the forest standing on land at one time subjected to the barbarous system of cultivation known as *jhooming, kumri, kil, toungya, dhaya, &c.*, in the various provinces of India, which consists in clearing and burning off all the vegetation on the ground, raising one or two crops on the ashes, and then taking up fresh areas, not to return until the forest is again old enough to yield a sufficient supply of ashes. Such are many of the pure teak copses of the Sathpuras, &c.

As artificial examples of this First Case we may quote plantations formed of a single species.

SECTION II.—SECOND CASE.—*Pure crop composed of individuals of all ages.*

In this case, contrary to what happens in the one just treated, the struggle for existence is always going on without lull or relaxation. New plants are constantly being produced wherever the leaf-canopy opens out sufficiently to allow them the smallest chance of life. Here the determining conditions for the survival of the fittest are—

I. INNATE VIGOUR.—The importance of this condition is not so great as in the First Case, for Condition V (which see) may quite nullify it.

II. GREATER SUITABILITY OF SOIL AND SUBSOIL.—This condition acts here exactly as in the First Case, with this addition, however, that where the soil is very wet or stiff, the older plants possess the advantage ; and, inversely, where the subsoil is impenetrable sheet rock or clay, or impermeable to water, or, on the other hand, waterless, the younger plants are able to live, while the older wither, decay, and die off as soon as their roots reach this unfavorable subsoil.

III. DEATH, DISEASE, UNHEALTHY STATE, OR RETARDATION OF GROWTH BROUGHT ON BY CAUSES EXTRANEOUS TO THE CROP, *viz.* :—

(*a.*) *Attacks of insects and other animals.*—The same remarks hold here as in the First Case. Besides this, it must be mentioned that animals, especially cattle and deer, are less likely to damage large than small plants.

(*b.*) *Attacks of parasitic and epiphytic plants.*—Exactly as in the First Case.

(*c.*) *Damage caused by climatic influences.*—The remarks made under the First Case apply with still greater force here. Young plants, coming up under lofty trees, will be perfectly safe against frost, hot and cold winds, snow, and, to a great extent, from drought and hail ; on the other hand, the drip from the trees above might prove dangerous to young seedlings. Again, the older individuals, with large and long roots, extending everywhere in the direction of moisture, are guaranteed against the severest and most protracted drought.

(*d.*) *Damage caused by fire.*—The effect of this condition

is the same as in the First Case, except that the young plants, as compared with the formed trees, especially if they are conifers, and hence, as a rule, unable to shoot up again from the collum of the root, stand little chance of resisting a fire.

(*e.*) *Floods.*—In this case there can be no doubt that the larger trees of the crop will resist much stronger and heavier floods than their smaller companions, even if the species in question is a denizen of flooded land. For further observations refer to the First Case under the same head.

(*f.*) *Injuries caused by felling, conversion and export operations.*—It is obvious that the younger and more slender the plant is, the more damage will it suffer from this cause. Nevertheless, within certain limits, the younger tree will recover sooner than an equally damaged old tree.

(*g.*) *Climbers.*—Exactly as in the First Case. Climbers are no respecters of age, nevertheless a large tree will obviously succumb less easily when attacked than a smaller one.

IV. DENSITY OF THE LEAF-CANOPY.—All the remarks made under this head in the First Case apply with more force here. As said there, the young plant of any species is more shade-bearing than its older fellows, and this difference is most marked in the case of trees that are very partial to light, like the teak, *Hardwickia, Pinus longifolia*, sal, &c.

V. AGE.—In a general sense the older plant will be stronger than one some years younger; but a time arrives when the vigour of a tree diminishes, its crown contracts and becomes spare, letting in light and forming gaps in the leaf-canopy. The younger trees, hitherto overtopped by it, but now endowed with greater vigour, are henceforward able to push up through these openings, pressing in still more the crown of their old companion until they finally hasten its death.

Examples of the Second Case.

Instances of the Second Case are abundantly offered by large tracts of *Pinus longifolia* forest in the North-West Provinces and the Punjab; of babul and of sissoo in Northern India, in Sindh, and in the Northern Deccan; of khair and of sal in Northern and Central India; of *Hardwickia* in Central and Southern India; of *Mesua ferrea* in Assam, &c.

SECTION III.—THIRD CASE.—*Mixed crop composed of individuals of one and the same age.*

In the two preceding cases we had to deal with pure crops, the individuals of which necessarily differed from each other only in respect of comparative vigour, size, and age. In this, the Third Case, a very complicated element enters, for no two species, however similar to each other they may be, can possess the same habit of growth, or the same requirements

as to soil, climatic influences, and locality, or the same longevity or vitality, or the same liability to damage from various causes, or equal facility of reproduction, &c. Hence the conditions which determine the survival of the fittest plants of the crop are much more numerous, and extremely complicated by their acting simultaneously, and often more or less nullifying each other, or producing joint effects which sometimes defy analysis. Their consideration is also all the more difficult, as they run one into another, and cannot always be studied apart.

I. INNATE VIGOUR.—Though not less important here than in the two preceding cases, this condition has not so far reaching an effect as those which follow, for these latter may totally nullify any advantage possessed by a plant in respect of innate vigour alone.

II. GREATER SUITABILITY OF SOIL AND SUBSOIL.—The influence of this condition is extremely great, and is sometimes the sole effective cause of a forest being more or less pure. Thus, for instance, the eng *(Dipterocarpus tuberculatus)* will drive out all other species from laterite in Burma, the *Terminalia tomentosa* the teak from wet binding soils in the Central Provinces. The sissoo alone can grow on the alluvial shingly banks and beds of some rivers; and so on. Even in a limited area the soil may vary from point to point in respect of one or more of its principal properties—physical and chemical composition, depth, hygroscopicity, compactness—all these various differences favouring one species at the expense of another, besides producing marked differences in the vigour of plants of the same species.

On shallow soils resting on a compact subsoil, surface-feeders will thrive better than trees that send their roots deep into the ground; and similarly species that throw up suckers than others not possessing that faculty, which, indeed, is increased in such soils.

The soil also influences reproduction to a very considerable extent. If it is hard or caked at the surface, or dry, species producing seed which germinate with difficulty, *(e.g.,* teak, &c.), or are so large that they are either washed away or insufficiently covered (teak, the *Terminalias*), stand little chance against such of their companions as produce smaller seed that is caught in little crevices or depressions (*Anogeissus, Rhododendron,* &c.), or seed that germinates more readily (sal, &c.). Moreover in such soils, species, the young seedlings of which develop a strong taproot, capable of forcing itself into the ground *(e.g.,* teak, sal, &c.), are bound to prevail over their less favoured companions. In loose, free, moist soil the victory will obviously be little dependent on the size of the seed.

III. DEATH, DISEASE, UNHEALTHY STATE, OR RETARDATION OF GROWTH, BROUGHT ON BY CAUSES EXTRANEOUS TO THE FOREST, *viz.*—

(a.) Attacks of insects and other animals.—The remarks made under this head for the first two cases are equally applicable here. Besides this, we know that with many insects certain species are characteristic of, and limited to certain kinds of trees, that cattle and deer will greedily devour the foliage of some kinds and leave others untouched; and so forth. Thus, for instance, it is not uncommon to see every teak leaf over large tracts of the Central Provinces eaten up by a certain species of caterpillar in the space of a few days, while the foliage of the various companion species entirely escapes the pest. Similarly, the foliage of sal is attacked and more or less completely devoured over large areas by the larva of a certain species of insect *(Tinia)*. Again, a borer *(Cerambyx)* often attacks young teak shoots, piercing the wood up to the pith, where it lodges, and thus either kills the portion of the shoot above the wound, or stops or retards its growth, or allows it to be easily snapped off by the wind. In some of the forests in Saugor, in the Central Provinces, young *Stephegyne parvifolia* have no chance of getting up, as the tender annual shoots are devoured by deer as fast as they come up. So in the Himalayas, *Quercus incana, dilatata,* and *semecarpifolia,* can never rise above a mere bush where grazing is unrestricted. On the other hand, *Hardwickia* and, in many places, sal seedlings are seldom, if ever, touched by the mouth of cattle.

The intervention of man also exercises a greater influence here than in the preceding cases, and not unfrequently results in the complete banishment of certain species. Large and frequent clearings for cultivation or other purposes may enable the more vivacious species to get ahead of, and suppress, all others (examples, teak, *Ougeinia, Zizyphus,* &c.). A large demand for certain kinds of produce may create a heavy run on the few species which furnish them, and thereby enable their companions, even those which are naturally less fitted to survive, to fill up the vacancies left by them, and secure the mastery.

(b.) Attacks of parasitic and epiphytic plants.—All the remarks made under this head for the First Case apply also here. Moreover parasites are nearly always selective, preferring some species to others, or living exclusively on a single species; and so, although to a much less extent with many epiphytes. Thus the *Arceuthobium Oxycedri,* as far as is known, grows in India only on the *Juniperus excelsa,* gradually overspreading the plant on which it has once taken root, often killing the branch or the entire tree. Precise information under this head is wanting in India, and more careful and extended observations are urgently called for.

(*c.*) *Damage caused by climatic influences.*—Under this head we will include injury suffered from the causes in question by *individual plants*, irrespective of the influence they exercise on the *general growth* of each species considered collectively. The consideration of this influence introduces a much larger question, the extreme importance of which requires that it should be treated under a separate major head (see No. VIII below). This reservation being understood, no further remarks are called for than what have already been made on this subject under the first two cases.

(*d.*) *Damage caused by fire.*—The influence of this source of injury is very considerable. First of all, it may be said, that broad-leaved species resist fire better than conifers, since the first are able to recover, thanks to their faculty of shooting up again from the stool; whereas the latter (*Pinus longifolia, deodar, yew and larch excepted, strong plants of which are* sometimes able to grow up again from some point close to the ground) are killed outright once the vitality of their buds is destroyed. And besides this, as the needles, cones, fallen twigs and branchlets, and the bark of conifers are always more or less resinous, the relative severity of any conflagration that may occur is naturally very great, and standing trees, with thick dry bark full of resin, are easily exposed to be burnt down. In the second place, as regards the broad-leaved species themselves, their degree of resistance to the effects of forest fires will depend (i) on the evergreen or deciduous nature of their foliage; (ii) on the vitality of the collum of the root; (iii) on their ability to throw up suckers; (iv) on the number and vitality of their dormant buds; (v) on the density of their foliage; (vi) on the season at which they put forth new leaves; (vii) if they are deciduous, on their season of leaf-fall; (viii) on the time of the year at which they shed their seed; (ix) exceptionally on the ability of their seed to resist the destructive effects of fire; (x) on their ability to form at once a strong new leader when the original one has been killed; and (xi) on the vivaciousness of the bark, *i.e.*, the readiness with which it re-forms under burns, cracks, &c.

With regard to (i) it is evident that with an evergreen leaf-canopy the moisture of the soil would be maintained at its maximum, there would be little combustible undergrowth on the ground, and, if ever a fire occurred, it would only smoulder, or at the most rise only a few feet above the ground. With respect to (ii) it is obvious that the persistence of young plants, especially before they have become saplings, is due almost entirely to their ability to throw up shoots from the collum of the root when their aerial portion has been destroyed by fire. As for (iii) it is well known that when any species is able to throw up suckers, forest fires, by weakening the standing individuals, only increase this tendency; witness the large stretches of

almost pure *Ougeinia dalbergioides* in the dry forests of the Sathpuras. As regards (iv) it is evident that the greater the number of dormant buds is, the more likely are there to be some that have escaped destruction. With respect to (v) it is enough to say that trees with dense foliage have naturally very little undergrowth below them with which to feed the flames and draw them up into their crowns. For instance, *Hardwickias*, with their open foliage, encourage a close undergrowth round their trunks, the consequence being that, when fire comes in, the flames rise up to the summit of the highest crowns, which, although quite green, blaze up like tinder. With reference to (vi) everyone knows that, if a fire occurs when the new leaves are in the process of coming out, they are generally all destroyed, and the trees that are not killed outright can put forth only a very poor second flush in consequence of the paucity of the surviving buds. Again, should a fire occur before the buds begin to swell up, preliminary to bursting into leaf, it is a physiological fact that their vitality, owing to their then containing a minimum quantity of moisture, is less easily destroyed than afterwards. Hence, generally speaking, even irrespective of the fact that the brushwood and herbage below is then drier, the later a fire occurs the more likely is it to find the trees either in full leaf or with the new flush just coming out, and hence the more likely to do greater damage. In connection with (vii) it is obvious that the longer the leaves persist, the less will probably be the quantity of inflammable material on the ground; and besides this, the violence of any fire that may occur will be proportionately diminished by the impediment to the production of wind offered by the standing mass of foliage. With regard to (viii) it is a truism to say that if fire enters after the seed has fallen, there is very little chance of any of it escaping. With respect to (ix) we know that the fruit of some species, like the teak, the *Terminalias*, and others, can stand a very high temperature, less or more prolonged, without the germ being thereby killed. As concerns (x), it is evident that species, individuals of which can at once re-form a new leader when the old one has been killed or broken off, possess a considerable advantage over others which possess this faculty in a less degree. Lastly, what we have said under (xi) is obvious and requires no explanation.

(e.) Floods.—All previous remarks under this head apply equally well here. Moreover, the extent of damage done by floods depends on the different species according to the respective degrees of resistance they offer to a rush of water, and to the respective ability of each to withstand the temporary excess of moisture round all its roots. For instance, in most sundri forests the ground is muddy throughout the year. Sissoo, khair, babul, *Terminalia arjuna*, &c., can flourish

with the soil under water for a more or less long period, whereas teak, sal, and other species are, to say the least, thrown back if the floods last any time.

(f.) Injuries caused by felling, conversion, and export operations.—The ability of a plant to resist such injuries will depend—

(i). On its faculty of shooting up again from the collum of the root, or of throwing up suckers from the roots.

(ii). On the firmness and strength of its roots.

(iii). On the strength and elasticity of the trunk.

(iv). On its ability to re-form at once a strong leader, when the original one has been broken or killed.

(v). On the vivaciousness of the bark, *i.e.*, its readiness to form and close over wounds and bruises.

All these points are self-evident, and require no explanation.

(*g*). *Climbers.*—The remarks made under this head in the First Case apply with equal force here. Besides this, it may be added that climbers are in no sense selective as regards the species of tree along which they rise above the ground. Usually they are confined to rich or at least moist soils, and are hence peculiarly destructive to species that affect those soils.

IV. DENSITY OF THE LEAF-CANOPY; RELATIVE DENSITY AND SHAPE OF CROWN, AND RELATIVE CAPABILITY OF PERSISTING UNDER OR PUSHING UP THROUGH COVER.—It will be noticed that the second clause of this heading is additional to what appeared in the two previous cases. Its necessity is evident, for with only a single species in the crop, all the plants are necessarily equally able or equally unable to persist under or push up through cover overhead; whereas the moment a second species enters the crop, the relative ability of the two in this respect becomes a most important element in the mutual struggle for existence, and has hence to be considered. Moreover, the relative density and shape of the crown of any species regulates, to a considerable extent, its proportion in a mixed crop.

As a rule, the denser the foliage of a species is, the more shade-bearing will young individuals of it be. Instances in point are deodar, silver fir, mango, *Buchanania latifolia*, *Eugenias*, laurels, *Terminalia tomentosa*, *Diospyros Melanoxylon*, *Stephegyne parvifolia*, *Mimusops indica*, *Pongamia glabra*, bamboos, the holly, *Quercus incana*, &c., &c. Hence those species have obviously, as far as this condition alone is concerned, a great advantage over such of their companions as are shade-avoiding, the crowns of which are generally more or less open. While young individuals of the former can ultimately get up into the leaf-canopy above, which end is rather facilitated than otherwise by the overhanging trees of the other class acting as nurses, the young of these latter are not only subject to suppression by the leaf-canopy above, but are also elbowed out by

their shade-bearing companions in the undergrowth. Thus where sal and *Pinus longifolia* meet, although pine seedlings are produced in abundance, they are very soon choked up and overtopped by young sal, which gives them no chance of existence except where the soil is too poor and dry for it. Similarly, although deodar and the silver fir are both shade-bearing species, still the superiority which the latter possesses in this respect, gives it a complete mastery over the other on moist aspects, the young silver fir being able to live with unimpaired powers of recovery under dense cover up to 30 and 40 years of age, and even more.

Some trees there are, which, although after a certain age they cannot flourish except with their crowns free on every side, yet, during their early years, are able to stand a great deal of shade. A very remarkable instance of this is the *Hardwickia binata, seedlings of which will persist under* dense and even low cover for ten years and upwards. Again young *Pinus longifolia* seedlings are not unfrequently to be found, if not absolutely vigorous, still full of vitality, under low, bushy *Quercus incana.* Nay teak itself will live for years as undergrowth in forests of medium density, consisting of bamboos, *Pterocarpus Marsupium, Terminalia tomentosa, Cochlospermum Gossypium, Boswellia thurifera, Hardwickia binata, Anogeissus latifolia,* &c.

The shape of the crown also exercises a considerable influence on the struggle for existence. Sal, with its long narrow crown, is able to push up through any small gap it may find in the leaf-canopy above it. Shade-bearing trees will at once spread out a branch here and a branch there into any interstices they find. Of two species growing side by side and possessing similarly shaped crowns, but one of which is more shade-bearing than the other, the second will ultimately disappear; whereas a third species, although much less shade-bearing than the second, but with a differently shaped crown, will be able to occupy a permanent place in the leaf-canopy.

Lastly, the relative ability of trees to push up through cover has to be considered. Facility for doing so, added to the faculty of persisting under cover, gives a tree, possessing it, an irresistible superiority over its neighbours. The manner in which young deodar makes its way through the dense crowns of overhanging oaks and rhododendrons is an excellent instance in point. But there are certain shade-avoiding trees also, which, thanks to this facility, are able to force themselves not only into, but through, the leaf-canopy above. Such species are either comparatively very rapid growers, or, from being in leaf and putting forth new shoots while their companions are entirely leafless, are able to spread out, both laterally and upwards, in spite of being overtopped or pressed in by

the crowns of these latter. The most remarkable instance of the first case is that of the *Dendrocalamus strictus* and other bamboos generally, which, although extremely partial to light, will shoot up through the loftiest and deepest cover. Again, the strong leader of the teak will, provided it has not far to go to reach direct sunlight, pierce through the thickest tangled mass of foliage overhead. The second case is best illustrated by the *Hardwickia binata*, young plants of which gradually insinuate themselves through the crowns of the trees immediately above them, especially of khair and, of course, of *Boswellia*. Indeed the finest saplings are often those which have grown up in this manner through khair (see Condition XII, *infra*.)

V. RELATIVE LONGEVITY.—This factor has a most important influence on the struggle for existence. That influence is so great that of itself it enables a species, placed at a disadvantage with regard to its companions in most other respects, to prevail in the end. The best instance of this is offered by the teak, which, in spite of every kind of ill-treatment, and of an ungrateful soil and climate, is able to form extensive copses on the dry barren hills of the Sathpuras and Southern Vindhyas. In the same way the sal, although gregarious and fast growing species like the *Tetrantheras*, bamboos, &c., may gain the upper hand of it at first, still lives long enough to see these disappear and leave it in complete possession of the ground. Indeed the greater longevity of the more valuable species seems to be a special dispensation of nature, otherwise useless and inferior kinds, like the *Cochlospermum Gossypium, Kydia calycina, Helicteres Isora, Mallotus philippinensis, Zizyphus, Mimosa rubicaulis, Indigoferas, Justicia Adhatoda, Blumea, Buddleia, &c.*, would simply choke up and drive out all better growth.

VI. RELATIVE RAPIDITY OF GROWTH.—The influence of this cause will be different according as this relative rapidity obtains during the first years of the life of a tree or at a later age. Other circumstances being equal, it is evident that species which grow rapidly during their early years will prevail over others which are of slower growth at that age. And similarly stool-shoots and suckers will very soon smother out any seedlings that may come up simultaneously with them. In the habitat of the teak, bamboos everywhere, *Butea frondosa* in Central India, and some other species, complete at least half their growth before that valuable tree only begins to push upwards, the consequence being that, unless this last has a real start, it is completely driven out. In most sal forests, besides the bamboo, it is the *Tetrantheras* that push up rapidly and cover the ground, while the sal is only just establishing itself. Among the companions of deodar, the *Pinus excelsa* shoots rapidly away soon after it germinates, and leaves that tree far behind in the race. It is thanks mainly to the wonderful

rapidity with which teak stool-shoots grow up, that that species is so easily able to hold its own in the coppice forests of the Sathpuras and the Western Ghats. On the other hand, when growth becomes rapid only after the plants have attained a certain age, its vigour in the case of the larger trees of the forest is always so great that nothing can withstand it. It is thus that when teak has survived up to this stage it overcomes every obstacle to its growth, and so with sal, deodar, *Pinus longifolia*, *Hardwickia binata*, &c

VII. RELATIVE MAXIMUM HEIGHT ATTAINABLE.—This condition finally decides what trees, out of those that survive up to a certain stage of growth, shall form the crop, or, if there are species present which are shade-bearing enough to constitute a permanent undergrowth, its upper story. Of the companions of sal there are only the *Terminalias*, some *Albizzias*, *Adina cordifolia*, *Pinus longifolia*, some *Eugenias*, and half a dozen other species which attain the same height as that noble tree, and which, therefore, compete with it for a place in the lofty leaf-canopy of the full-grown forest. In most of the forests of Central India (including Northern Bombay), teak is a small tree, and is hence easily beaten by its taller companions. Deodar is, as a rule, the tallest tree in the forests where it grows, whence its gregariousness in those places, where other circumstances, such as soil, moisture, &c., are favorable. Again, *Mesua ferrea* is, with the exception of *Altingia excelsa*, the tallest tree in the large areas which it covers almost by itself in Assam. The teak in Burma, and the *Artocarpus Chaplasha* in Assam, although unfavorably circumstanced in many other respects to struggle for existence with their companions, are able to hold a permanent place in their midst. In evergreen forests trees of deciduous species tower above all the other growth.

VIII. RELATIVE SUITABILITY OF CLIMATE.—This is perhaps one of the most important conditions in the struggle for existence, for in almost every case it determines the habitat of the various species, and also the vigour of their growth. Many factors go to make up what is called climate, and they may best be considered separately :—

(a.) Heat and frost.—The influence of these factors is due chiefly to extremes, being very little or scarcely appreciable within limited ranges of temperature. Thus the minimum temperature of the cold weather months in the region of teak ranges from several degrees below frost in Narsingpur in the Central Provinces, to 59° in Bombay and in Rangoon, the mean temperature in those places during the same months being respectively 62°·4, 75°·7, 75°·6. It is only when these extreme ranges are approached that the teak has to give way to other species. In Sindh, the Chaors and Kachas along the lower course of the Indus are covered chiefly with babul;

higher up the river frosts become very severe, and tamarisk gets the upper hand of babul. In the Changa Manga Plantation frost has killed out the babul, and left the sissoo complete master of the ground. Sal retreats before the hot dry winds of the open plains of North-West India. Nevertheless within one and the same habitat some species resist frost, or recover from injury caused by it, much better than others. This fact accounts for the actual proportion or entire absence of certain species in many forest crops. Thus teak, the young plant of which is very sensitive to frost, is eliminated or kept down by it in many tracts in the Central Provinces and in the northern portions of the Bombay Presidency. For the reason that khair and sissoo stand very low temperatures, they grow almost pure in damp, low, frosty situations. On exposed southern slopes *Pinus excelsa* drives out deodar.

The sensitiveness to frost of plants is directly proportional—*(i) to the size of the leaves and the roughness of the buds*, leaves, and internodes ; (ii) to the quantity of water in the cell-sap as compared with solid substances ; (iii) to the looseness of texture of the living tissues ; (iv) to suddenness of thaw ; (v) to the thinness and late formation of the outer covering of dead bark (the *rhytidome)* ; (vi) to shallowness of rooting ; and (vii) to the quantity of watery vapour in the atmosphere. We may hence deduce the following corollaries, granting always that other circumstances are equal :—(*a*) the more active the vegetative processes during the season of frosts, the more sensitive the tree ; (*b*) the greater the number of dormant buds, the hardier the species ; and (*c*) the more generous the growth of a young plant, the slighter its power of resistance.

Besides influencing the development of individuals of the various species, temperature also affects their ability to bear flowers and fruit (see Condition IX, *a* and *b*).

(*b.*) *Damp and drought.*—Here also only extremes act. For instance teak seems to thrive best under a mean annual rainfall of from 50 to 120 inches, but does not disappear till the fall decreases to about 24 inches. Even the range of rainfall for sal extends roughly over 80 inches, *viz.*, from 40 to 120.

In the dry climate of Rajputana the *Anogeissus pendula* easily gains the ascendancy over all other species. The jand (*Prosopis spicigera*) finds no rival or compeer in the dry rakhs of the Punjab.

Under damp must be included, besides rainfall, also relative humidity. The sal will acquire its finest dimensions in the hot steamy valleys of the Lower Himalayas, but refuse to grow in Chanda and other places where the temperature during the hot weather is scarcely higher, but where nightly dews are neither heavy nor occur during any considerable part of the dry season. Possibly the natural spread of sissoo, south of

its range, is limited by the drier atmosphere of the adjoining region. The very high relative humidity of the inner ranges of the Himalayas enables evergreen species to prevail there, notwithstanding the low rainfall they receive.

The abundance and continuousness of rain at the beginning of the rainy season exercises a very strong influence on the germination of the seeds of the various species. The seeds of some species have to go through a long process before they become perfect plants. A sudden break in the rains, and a few hours of strong sunshine during this process, might kill the majority of such germinating seeds. This happened over several square miles in the Khandwa Reserve in Nimar, in the Central Provinces, in 1879, in the case of the *Hardwickia binata*. Again, if the monsoon rainfall is at first short, and the seed of any species, like teak, which requires plenty of moisture, germinates in consequence only in the latter half of the season, the young herbaceous plants must fall easy victims to the hot sun of October and November and the frosts of December and January.

Lastly, it may generally be said that those species, the seedlings of which develop a strong, long taproot, will withstand severe and continued drought and thus survive, while others, less favoured in this respect, will disappear or be left in the minority.

Besides influencing the growth and soundness of individuals of the various species, the amount of atmospheric moisture affects also the abundance and frequency with which they flower and seed (see Condition IX, *a* and *b*).

(*c.*) *Light, its intensity and duration.*—Here also it is the action of extremes that exercises any appreciable influence on the struggle for existence. Some species cannot make any useful growth, except under exposure to direct sunlight. These form the majority of our Indian species, and include teak, sal, &c. Others, like the *Quercus incana*, silver fir, &c., will flourish and attain their finest dimensions even in diffused light, without seeing a single direct ray from one end of the year to the other. The figs require a great deal of direct sunshine, and hence their arboreal habit. Going out of India to Northern Europe we have the Scotch fir and birch delighting in almost perpetual sunshine during half the year, and able to survive almost endless night during the other half. As rather more than one-half of India is situated within the Tropics, and of the rest the greater portion consists of level ground fully exposed to the sun, and within a few degrees of the Northern Tropic, the climatic influence of light, as opposed to so much of it as was considered under Condition IV, is not important except for a very few species, such as the *Pinus excelsa*, deodar, and some other Himalayan trees, which require good illumination, but cannot stand heat, both

of which conditions are satisfied by the altitude at which they grow. But this is anticipating subhead *(e)* below.

Besides influencing the development of individuals of the various species composing a forest crop, the greater or less intensity of the light acting on their crowns, according to their different degrees of isolation, also affects the frequency and abundance with which they flower and seed (see Condition IX. *a* and *b*).

The intensity of light being the same, the longer its duration is, the more shade will the various species be able to bear, and *vice versa*. Then, again, the more intense the light is, the better are the various species able to grow under cover, and form a dense leaf-canopy. And, lastly, diffused light is more powerful in its effects on vegetation at high than at low altitudes (see Condition IV, under First Case).

(d). *Aspect.*—In hilly and mountainous country the influence of this condition is very great, often of itself determining the distribution of certain species. In Southern Nimar, in the isolated block of hills known as the Sambar Deo range, on the left bank of the Tapti, the southern slopes bear *Hardwickia binata*; while the northern ones, being cooler and moister, are covered chiefly with a dense teak copse, a rare *Hardwickia* being visible here and there. In the outer North-West Himalayas, *Pinus longifolia* generally affects the warm southern and eastern aspects, while oaks with rhododendron clothe the northerly and westerly slopes. Nevertheless lower down, where sal and that pine meet, the latter, which is a tree of a colder climate, is represented chiefly on northerly and westerly slopes, the sal occupying the warmer aspects. Going up higher, into the region of deodar, *Pinus excelsa* is the ruling tree on southerly aspects; silver fir, spruce, *Quercus dilatata*, and *semecarpifolia*, with maples, birch, *Celtis australis*, &c., predominate on cold northerly and westerly aspects; while deodar prevails in the middle ground.

In dry districts in Central and Southern India the *Dendrocalamus strictus* affects the cooler northerly and westerly slopes; whereas in Bengal and along the foot of the Himalayas generally, where the climate is damp, it is found chiefly on the warm southerly faces of the hills. In other words, the aspect affected by a species may vary with the amount of atmospheric humidity of the localities in which it grows.

Aspect is always intimately connected with altitude, as will be seen under the next subhead.

(e). *Altitude.*—The main effect of altitude is to reduce temperature, but it has, besides the important effect of prolonging the duration of sunlight, and, by reason of the clearness and rarity of the atmosphere due to it, of increasing the effect of the sun's rays. Hence it often reverses the effect of aspect, as we have already seen under the preceding subhead in the

instance of the *Pinus longifolia*. Another example is to be found also in the outer Himalayas in Kumaon, where oak forest, although chiefly confined to cool northerly and westerly aspects, takes complete possession of southern slopes from the line where *Pinus longifolia* stops. At the upper limit of tree vegetation the effect of aspect is entirely nullified by altitude.

(*f*). *Winds, their direction, violence, and prevalence.*—The influence of winds on the struggle for existence between the plants of a forest crop is threefold. In the first place, by their violence they can uproot, injure the roots of, break off, and mutilate, distort, and stunt the trees; in the second place, they can alter the relative humidity of the locality according as they are drier or moister than the latter; and in the third place, they can reduce or raise the temperature according as they previously pass over a colder or hotter region. And all these various effects may be slight or aggravated according as the wind is intermittent and local, or constant and of long duration.

Of two trees of the same species, that one will resist better the force of the wind which possesses the broader crown, since the extent of the roots is proportional to the size and vigour of the crown. Again, of two species, one may be deep-rooted, while the other has its roots more or less superficial, and is consequently less able to resist violent movements of the atmosphere. Hence where storms and gales are frequent, as on ridges, spurs, peaks, in narrow gorges, or on the sea coast, the strong-rooted individuals will be the ultimate survivors; and species with weak superficial roots will have to retreat to sheltered localities.

IX. SEEDING.—This condition may be considered under six subheads, as follow :—

(*a*). *Its relative abundance.*—It is evident that, other circumstances being the same, a species that produces abundant crops of seed will, even if at first in the minority, secure an easy predominance. Instances of profusely seeding species are bamboos (*facile principes*), sal, sissu, deodar, *Quercus incana* and *semecarpifolia*, *Pinus longifolia*, teak, &c. In the Dehra Doon *Excæcaria sebifera*, an exotic, drives out indigenous trees in most places where it has established itself, thanks to its abundant annual seeding. In Mauritius *Tetrantheras*, *Albizzia Lebbek*, and other trees, introduced from India, and seeding more abundantly than the indigenous trees, now occupy by themselves whole hill sides.

Some trees, which are accommodating to climate, although abundant seeders in the heart of their habitat, produce only a small crop of seed near its confines, as, for instance, teak, *Pinus longifolia*, &c.

Of two species possessing equal longevity, that which seeds at an earlier age is also the one that seeds more abundantly.

For instance, the teak, babul, *Anogeissus*, sissu, sal, &c., are, among our species, those which seed in greatest profusion.

Some species require a larger total sum of heat than others in order to flower, and hence also to seed. Hence comparatively poor seed crops where a species occurs in a climate appreciably colder than that of its main habitat.

Again, some species require a less degree of isolation for their crowns than others, in order both to flower and bear fruit. Such species are also always more shade-bearing. Hence in a more or less completely canopied forest this class of trees will form more or less exclusively the next crop of seedlings, and consequently either drive out or leave in the minority their companions (if any exist) less favoured in this respect, even if these latter at first predominate in numbers. Thus sissu, khair, *Dalbergia latifolia*, *Anogeissus pendula*, &c., require less isolation than teak, *Pterocarpus Marsupium*, &c.

Lastly, all woody species produce most flower buds in a dry year. But in the case of some of them, as for instance *Hardwickia binata*, sissu, khair, &c., once they have put forth blossoms, subsequent hot or cold weather scarcely affects the development and ripening of the fruit. With others, on the contrary, such as sal, teak, deodar, &c., if unfavorable weather does not result in the destruction of the entire crop of flowers, only a relatively small proportion of it survives to become mature fruit.

(*b*). *Its relative frequency.*—While with some species, like sal, sissu, khair, *Anogeissus latifolia*, *Anogeissus pendula*, *Terminalia tomentosa*, &c., generally, and teak and *Pinus longifolia* within the main range of their habitat, seed-bearing trees in numbers are never wanting in any year. With others, on the other hand, like the *Hardwickia binata*, some bamboos, &c., not a single tree will be found even in flower for several years together. Between these two extremes there are intermediate degrees, including the greater number of our arborescent species. Greater frequency of seeding is obviously a marked advantage in the struggle for existence. Nevertheless, as we have already seen in the case of bamboos, great profuseness can more than make up for long intermittence, even where the associated species seed abundantly every year. It is obviously when the species concerned is shade-bearing, and able to push up through cover, that frequent seeding alone, without combined abundance, gives it an easy predominance.

The annual or intermitteut seeding of the various forest species is, of course, due to their nature. For instance, the bamboos will, under no circumstances, throw up flowering shoots every year in a general manner. But even with trees which produce inflorescence buds annually, the ravages of frost, drought, fire, insects, &c., will sometimes cause seed to fail. Such failure must be traced to the interval between the

appearance of the buds and their final change into ripe fruit. When this interval is long, successful seeding is exposed to all the fatal risks just enumerated. Thus between the appearance of the flower bud and the maturation of the cone of the deodar more than a whole year elapses, with the consequence that seed fails on an average in one year out of every four. Whereas the corresponding interval in the case of the companion firs, which ripen their cones at shorter intervals, does not exceed nine months, and the bursting forth of their buds, and the whole process of fructification, occurs between April and November of the same year, *i.e.*, during the mildest months. Similarly, teak near its northern limit in India, although it flowers abundantly every year, sometimes fails to form fruit owing to the heavy frosts of December and January. And so with *Terminalia tomentosa*, &c. On the other hand the entire activity of the inflorescence bud of sal is accomplished between March and the following June, so that, unless fires are so exceptionally severe as to scorch up every green thing in the crowns of the trees, or insects are exceptionally numerous and destructive, a certain quantity of seed must be produced every year.

Some species, like the *Hardwickia binata* for instance, produce flower-buds only in very dry years. Drought has also, no doubt, some influence on the flowering of bamboos, which frequently coincides with years of scarcity. And, indeed, drought may generally be said to favour the production of flower-buds by weakening and diminishing the foliage of the trees.

Frequency of seeding is also dependent on the density of the leaf-canopy, some trees, as already stated under (*a*), requiring a less degree of isolation than others to produce flowers and fruit. For instance, it is a matter of common experience in Assam to find isolated individuals of *Mesua ferrea* loaded with fruit, while the seed collector wastes his pains in canopied masses of that species.

(*c*). *Size and transportability of the seed.*—Large and heavy seeds like acorns will drop almost vertically on the ground, while the minute seeds of *Stephegyne*, *Adina*, *Andromeda*, &c., will be blown away to considerable distances by the slightest wind. But large and heavy seeds may, thanks to foliaceous or comaceous appendages, such as are found in teak, sal, *Pterocarpus Marsupium*, *Terminalia tomentosa*, &c., be carried some distance off from the parent tree by wind. When small or light seeds are armed with such appendages they may be blown away for miles; for instance, hundreds of thousands of young *Stereospermum suaveolens* will be found covering several square miles which do not contain a single fertile tree of that species. Then again water may transport seed over long distances, as is strikingly illustrated by tamarisk, babul,

sissoo, khair, cocoanuts, &c. Another interesting example of this may be quoted. The nearest limit of the region of *Anogeissus pendula*, from the northern boundary of British Nimar, is not less than 150 miles along the course of the Narbada and its tributaries; nevertheless the banks of that river, where it runs through the dry Vindhyan barrier north of Punasa, is covered in places with a dense low growth of that species, the outcome of seed brought down the river and arrested there.

But the transport of seed is facilitated not only by its lightness, or its appendages, or by water, but also by its edibility. Thus the heavy seed of the *Diospyros Melanoxylon* is disseminated far and wide by bears, jackals, men, &c., who are greedily fond of its sweet pulpy fruit. So with various species of *Zizyphus*, with *Gmelina arborea*, *Myrica sapida*, *Schleichera trijuga*, *Buchanania latifolia*, the sandalwood tree, wild pear, *Terminalia Bellerica*, babul, *Tetrantheras*, *Michelia Champaca*, &c. Birds are active distributors of the seeds of the various species of Ficus and *Loranthaceæ*, depositing them on their future hosts in places favorable for their reception.

(*d*). *Season of fall of seed.*—In forests where fires are an annual occurrence, seeds shed at any time before that plague has passed through, are bound to be almost wholly destroyed, only a few escaping which fall on bare ground clear of combustible substances, or which belong to species, like the teak for instance, the seed of which can stand a high degree of temperature without being killed. Species like the sal, eng, toon, *Tetranthera monopetala*, &c., the greater proportion of the seed of which falls at the beginning of the rains, when the season for fires is over and all nature is green and damp, possess a very marked advantage over their associates. The gregariousness of *Quercus dilatata* and *semecarpifolia* is to a great extent to be explained by the fact that their acorns ripen and fall in the middle of the rainy season.

And, in a general manner, it may be said that the longer the interval between the fall of the seed and the ensuing rainy season is, the less chance is there of finding a large proportion of it fit to germinate when that season arrives.

(*e*). *Relative vitality of the seed.*—This condition has a most important influence on the reproduction of a species. Teak, although its seed is shed when jungle fires are about to commence, and has to lie for several months on the ground, exposed to various causes of destruction before the first fall of rain, is still able to reproduce itself freely, thanks to the extraordinary vitality of its seed, which even a certain degree of scorching will not kill, and which remains perfectly sound after several years of exposure to alternate damp and drought in the forest. On the other hand, the seed of the *Terminalia tomentosa*, unless it finds moisture enough to germinate at the beginning of the very first rainy season, at once rots and dries

up. Small seeds, like those of *Anogeissus*, *Stephegyne*, *Adina*, &c., are killed in numbers simply by the heat of the sun during the hot weather, and but for that circumstance, those species would easily overrun, as the two *Anogeissus* actually often do, the whole forest wherever it grows. As regards the *Anogeissus pendula*, however, water seems to exercise a great preservative effect on its seed, which, as already mentioned above, is carried down by river more than 150 miles, to germinate where it is deposited. This peculiarity is also well illustrated by the production of new forests of sissoo, khair, tamarisk, and babul.

(*f.*) *Relative facility of germination.*—This condition has a very marked effect on the reproduction of the various species composing a crop. Thus in sal forest, there is every year a more or less plentiful new crop of seedlings of that species produced, whereas, save in exceptional years and places, yearlings of the allied species are either wanting or are entirely in the minority. This is due to the sal seed germinating as soon as it falls, while that of the other species, although many of them are annually fertile, germinate with much less facility. Teak, in spite of its profuse and generally annual seeding, nevertheless, as a rule, produces every year only a very small number of seedlings, owing not only to the early fall of its seed, but, throughout India proper, chiefly to the excessive difficulty with which it germinates, having often, under the most favorable circumstances, to lie in the soil for upwards of two years. There are other species, the actual germinative process of which spreads over several days, so that when once that process has begun, if a sudden prolonged break in the rains should occur, and the soil dry up at the surface under a hot sun, it must be immediately arrested and the germ killed. Such species are *Terminalia tomentosa*, *Gmelina arborea*, &c. Again, the same class of seeds, for the very reason that their germination is protracted, are also often liable to rot from temporary excess of moisture. But the most striking instance of superior germinative facility giving an infinitely great advantage to species that possess it, is that of the grasses: whence the extreme difficulty of restocking open treeless land.

X. RELATIVE FACILITY OF GROWING UP AGAIN FROM THE STOOL.—All broad-leaved species can grow up again from the stool. None of the conifers possess this faculty; the *Pinus longifolia* and deodar, it is true, do often shoot up again from *near* the base, but never really *from* the base, which latter property is the essential characteristic of stool-shoots. But among the broad-leaved species themselves not only does the age, up to which the power of growing up again from the stool is retained, vary with different species, but also the abundance of the shoots produced. Teak coppices very freely up to a

great age, often beyond a hundred years, and it is due chiefly to this property that it forms nearly pure crops of large extent in the mutilated forests of Central India, Berar, and Northern Bombay. Sal also coppices more vigorously than most, if not all, its companions, except perhaps bamboo, and is hence easily able to hold its own, notwithstanding that, as a rule, it is, with bamboo, the only species in the forests in which it occurs that falls under the axe of the wood-cutter. And so with a number of other species, to wit, khair, sissoo, willows, *Anogeissus*, jand, &c.

XI. RELATIVE FACILITY OF THROWING UP ROOT-SUCKERS.—The faculty of producing root-suckers is limited to a very small number of trees, but in revenge those which possess it have a permanent important advantage over their companions. This faculty is usually strengthened by any kind of mutilation of the aerial portion of the tree, being greater in proportion to the amount of the mutilation. Moreover, it is favoured by the wounding of the roots, suckers generally springing up from the edges of the wound. And, lastly, it is strongest in shallow, stony or rocky soils.

In Central India, *Ougeinia dalbergioides* forms large masses of pure forest on land recently abandoned by cultivation, the husbandry operations having helped to multiply the number of suckers from the original plants. The same, although to a much less degree, may be said of the *Diospyros Melanoxylon* in the same forest region. One of the main causes of the predominance of *Boswellia thurifera* in the dry forests of Central India is the facility with which it throws up suckers. The gregariousness of sissoo in Northern India is also in a great measure due to the same cause, as is also the invasive character of *Buchanania latifolia* in Northern and Central India, and of *Excœcaria sebifera* in the Dehra Dun.

XII. RELATIVE DURATION OF FOLIAGE, AND SEASON OF ITS FALL AND RENEWAL.—This condition influences to a very remarkable extent the distribution and proportion of many species in a crop. It is evident that, other circumstances being equal, the longer a species remains in leaf during the year, the better is it adapted to secure ultimate mastery over its companions. A tree in leaf is constantly assimilating new material for its growth, and either spreading itself out in every direction, or preparing to do so, the result being that it is able to steal a march on its leafless neighbours, and this with conspicuously greater effect if the season for the renewal of its foliage occurs earlier. Thus, where the climate and soil are suited to evergreen species, these always predominate over their deciduous companions (see Evergreen Forests in Chapter III). In some parts of Burma evergreen species have invaded the confines of teak, and surrounded in their close embrace isolated trees of that species, which will now be the

last of their race there. Again, the sal, which is all but an evergreen, is able to suppress most of its would-be rivals. Thus in the Raipur district of the Central Provinces it has encroached on the teak in many places. The *Anogeissus pendula* is leafless for a few days only in spring, and tolerates few companions of other species. On the other hand, the *Boswellia thurifera*, besides possessing an open crown, is leafless for from eight to nine months; so that, although for other and more potent reasons it does grow gregariously, it nevertheless allows other species not only to push up into the leaf-canopy on a level with itself, but also to occupy a permanent and often large place there. Such species are *Hardwickia binata*, *Anogeissus latifolia*, teak, khair, &c., which all retain their foliage for some months after the *Boswellia* has shed its own, and renew it from several weeks to several months earlier. Indeed, in many localities, the *Boswellia* may be looked upon only as a temporary natural crop to be replaced by more favoured species to which it is now acting as a nurse, and which will drive it out when they no longer require its protection.

The number of flushes of new leaves that a species brings out during the year is also an important factor for consideration. Every new flush of leaves is accompanied with a sudden outburst of both lateral and upward growth, during which the tree is able to push up against and through obstacles, against which it may at other times be completely powerless. The *Hardwickia* produces at least two such flushes every year, and hence its ability to beat species much more shade-bearing than itself.

Lastly, where late frosts occur, trees that bring out new leaves early in the year will naturally suffer more than others whose foliage-buds begin to swell up, preliminary to bursting forth, only after the frosts are past. *Abies dumosa* suffers in this manner; and thus also is explained the impossibility of acclimatising deodar and the Indian silver fir in Northern Europe.

XIII. Gradient.—The effect of gradient, when there is no impeding cause, is to drain off the moisture of the soil. Trees like sissoo, the tamarisk, &c., require a great deal of water in the soil, and hence can grow only where the ground slopes very moderately. Other species, like sal, require a less quantity of water and a more perfect drainage; hence their affecting only steep or rolling hill sides, except, when, as in the Bhabar, the soil itself lets water pass through it as through a sieve. A third class, like teak, requires still less moisture in the soil, but does not object to a less free drainage; hence its ability to grow both on hill sides or on gently sloping ground with less or more binding soil. A fourth class, like the *Pinus longifolia*, requires even less moisture in the soil than the preceding but the most perfect drainage, and will hence, where the soil itself is not freely permeable, confine itself to slopes with

a gradient of at least 30°. A fifth class, like some *Euphorbias*, objects altogether to any very appreciable quantity of moisture in the soil, and hence where the rainfall is at all plentiful, will grow only on scarps; and so on.

But with species growing on hill sides it is not simply a question of drainage. The species must also have roots adapted to hold on firmly to steep slopes, and hence of two trees, similar in every other respect, that one will possess a decided advantage which has the stronger and more firmly-seated roots. Moreover, species with horizontally spreading main roots will do better on slopes than on level ground, since there half their main roots will be able to penetrate into the hill side, whereas on level ground every such root will be superficial, *e.g.*, oaks, *Cupressus torulosa*, &c.

XIV. RELATIVE DEPTH TO WHICH THE ROOTS PENETRATE.—This condition has a most important bearing on the distribution of some of our most valuable species. For instance teak, the *Terminalias*, &c., spread out their roots within only six feet and often less of the surface, so that in shallow soils resting on a perfectly dry subsoil, they yield the place to *Boswellia*, *Anogeissus*, khair, *Prosopis spicigera*, &c. The *Prosopis spicigera* itself has been known to force its main roots down to 60 feet below the surface of the water, and is, accordingly, able to flourish in the dry plains of the Punjab, whither no other tree can follow it. Again the sal is almost the only tree that can grow on the waterless boulder deposit between the foot of the Himalayas and the Terai, known as the Bhabar, the roots of that species being able to penetrate to a depth of certainly more than 60 feet, which fact accounts for its generally forming much purer forests there than in the hills. Many of the trees of the dry tracts of India, which bring out their leaves in the depth of the hot weather, like the *Bassia latifolia*, *Buchanania latifolia*, &c., have been known to send down their dense network of fibrous rootlets 20 feet below the surface.

Limiting the consideration of this condition to the case of young seedlings, it may be laid down as a general rule that the longer the taproot developed by yearlings of a given species is, the better are they able, other things being equal, to resist both frost and drought, and, therefore, the more likely is that species to predominate over every other that may be associated with it in the same crop. Instances in point are sal, *Hardwickia*, &c. The long taproot of the *Terminalia tomentosa* yearling enables it to survive severe and prolonged drought, without, however, affecting the natural sensitiveness of that species to frost. The deeper any layer of the soil is, the less exposed is it to changes of temperature due to subaerial variations, and the larger the proportion of moisture in it. Hence the deeper a taproot goes down, the more likely is it to find sufficient moisture, and the higher will be the temperature of the moisture which it pumps

up into the plant portion above during frosty weather—the one circumstance being a protection to the plant against drought, the other against freezing. And besides this, as during frost the water contained in a certain thickness of the soil, which thickness varies with the severity of the frost and the character of the soil, freezes and expands, causing the soil to swell up several inches, seedlings with a short taproot rise with the soil, and are hence left ejected when the latter subsides on thaw occurring. On the other hand, seedlings with a long and strong taproot are safe against such a catastrophe, unless the taproot is torn asunder by the up rising of the superficial layers of the soil.

XV. RELATIVE QUANTITY AND SPREAD OF THE ROOTS (INCLUDING THE RHIZOME).—Some species develop a close matted mass of roots and rootlets, which strangle the roots of other species growing with them. Some again also possess abundant spreading underground stems. The roots and rhizomes of species of *Carex*, *Andropogon*, &c., form a felt-like mass, often several feet thick, which strangle out all other growth. Once bamboo has taken possession of the soil, few individuals of other species can force their roots through the dense tangled mass of its fibrous roots; and conversely when the soil and locality are both suited to the growth of bamboos, no individuals of species with superficial roots can co-exist with them, only such trees as can spread out their roots below the layer of the soil monopolised by the bamboo having a chance of struggling successfully for a place in the forest crop. Hence the frequent inability of teak, *Terminalia tomentosa*, and other species possessing more or less horizontally spreading roots to cope with bamboos, which cannot, however, keep out sal and other trees with deep-seated roots.

XVI. A CLIMBING HABIT.—Under condition III (*g*) we have explained how climbers, considered as an extraneous accident in a forest crop, kill or at least weaken trees, and thus *assist neighbouring trees* in gaining the victory in the struggle for existence. In this place, on the contrary, we are concerned with the struggle between the *climbing plants themselves*, considered as forming an integral portion of the forest crop and the trees on which they climb.

Plants with a climbing habit rise up into and spread over the crowns of their supports, either (i) by means of adventitious roots, which enter the very smallest crevices in the bark, and attach themselves firmly thereto, *e.g.*, ivy, *Ficus scandens*, &c.; or (ii) by means of tendrils, *e.g.*, the whole genus *Vitis*, many rattans, &c.; or (iii) by means of hooked spines, *e.g.*, many rattans, &c.; or (iv) by twining round the stems and branches of their supports, at first in a loose coil, and then with a tight grasp, *e.g. Millettia auriculata, Spatholobus Roxburghii, Bauhinia Vahlii, Butea superba*, and a host of

other climbers; or (v) and lastly, by interlacing branches with, or simply resting up against or on the stems and branches of, their supports, *e.g. Zizyphus rugulosa*, &c.

Whichever the mode of ascension followed, the result is always the invasion and overspreading of the crowns of the supports by the dense foliage of the climber. The least harm done is impeded growth, and a sickly condition of the support. Moreover, when the climber ascends by twining, the stems and branches of the supports get constricted, the increasing pressure on the bark, following the entire circumference of the stem, prevents the free vertical diffusion of the elaborated sap coming from the leaves and other green parts; and finally, the channel for the passage of the crude sap from the roots becomes disproportionately smaller and smaller for the nourishment of the crowns, which become, in consequence, scraggy, sickly, and full of dead twigs and branches (the cause of future interior decomposition), and, if the trees form a heartwood, there is ultimately no sapwood left in their trunks, and death from sheer inanition is the result.

As with all other plants, so with climbers, the immediate effect of light is to retard the development of their tissues; and hence all climbers exposed to full sunlight and wanting a support become low erect bushes, or at the most assume a straggling habit. With defective illumination stopping short of the minimum absolutely necessary for assimilation in each case, climbers will form long internodes, and extend themselves vigorously; and indeed the largest of them are found in dense evergreen forests. Taking the special case of twiners, we know that the nutating end of the stem has comparatively small leaves and long internodes, exactly as if they grew in weak light, and this character is no doubt the result of a habit still continued, although the inducing cause (*viz.*, deficient illumination) is absent. We know, besides, that all climbers are shade-bearing, for without this quality they could not, as we know they do, make their way through the very densest crowns, as well as develop an aggressive mass of leaves in the midst of the already abundant foliage of those crowns.

To sum up: Climbers, no matter how they ascend, are able, thanks to their being shade-bearing to a very remarkable degree, to rise up into, invade, and overspread the crowns of neighbouring trees, no matter how dense. They thereby not only prevent these latter from extending themselves either upwards or laterally, but reduce the quantity of their foliage, kill and prevent the development of twigs and young branches, and induce premature decay and death. They are most destructive, if they are also twiners.

(*To be continued.*)

E. E. FERNANDEZ.

The Cape Forests.

Report of the Superintendent of Woods and Forests, M. le Compte Vasselot de Regne.

(*Continued from page* 1.)

II.

South-east Region.

Divisions of Uitenhage and Port Elizabeth

The eastern part of the division of Humansdorp contains no Crown forests.

The same is to be said of the divisions of Uitenhage and Port Elizabeth through which we passed.

Drift sands near Port Elizabeth.

The Harbour Commissioners at the latter town are carrying out works for arresting the sands deposited by the sea from the east of the Bay.

This work, commenced by some French workmen, has succeeded in attaining the desired object. There is no doubt it would be possible, without any increase of expense, to utilize these sands so far as they have been arrested, and it would be as beneficial to the country as to the proprietors if something of the kind were done.

Division of Alexandria.

We then visited the division of Alexandria. The Crown forests here are principally situated on very dry ground, the soil and sub-soil of which are very permeable, and contain a growth of timber of very little demand in the country.

Nevertheless, the trees mostly possess, according to Dr. Pappe, some properties which should render them useful for a number of purposes.

Sneezewood.

Sneezewood enjoys exceptional favour, comparable to that of stinkwood, in the south-west district: thus it has become scarcer than even this last kind, preserved hitherto in the Tzitzikama, on account of the difficulty of reaching it. Prompt measures should be taken forthwith to prevent the complete disappearance of the sneezewood, and afterwards to assure its reproduction and increase.

Forests of Olifants, Hoek, and Addo Bush.

The two principal forests, Olifants Hoek and Addo Bush, have not been surveyed. Their total area appears to be about 12,000 morgen, containing useful timber to the amount of 7,500,000 cubic feet, which should yield, annually, about 75,000 cubic feet.

Crown lots reserved.

The Government, in allotting Crown lands in this locality, has reserved the timber, which is found there. The total area of these blocks is estimated at 6,200 morgen.

The most important are situated in the Zuurberg. It would be sufficient, probably, in order to introduce timber here, to prevent any felling for a certain defined period, and to scatter, before cutting down trees, certain well-prepared seeds adapted to the soil.

Zuurberg. Lots: precautionary measures.

Lastly, it will be necessary to enclose the plantations in order to prevent injury to them by cattle.

The forests are looked after by a ranger, who does not appear to have any superior chief other than the Honourable the Commissioner.

I should here note the zeal and activity with which the present ranger, Mr. Nightingale, collected the information requested of him.

Nevertheless, the conservation is not carried out with sufficient efficiency, according to the present system.

There is an imperative necessity, before undertaking any improvements in this direction, for the presence, within a convenient distance, of an intelligent forest officer, capable of understanding the meaning, scope, and spirit of instructions which he would receive, and of being at the same time the counsellor, guide, assistant, and controller of the rangers of the province.

Superior forest officer recommended.

Yield of forests.

The forests of Alexandria produced in 1880, £273.

Firewood industry.

The total quantity of timber felled amounted to 26,120 cubic feet, and 273 loads of firewood.

This latter article has a substantial importance in this part on account of its proximity to Port Elizabeth.

The particulars of timber delivered, and the situation of the Crown lands of this division, are indicated in the annexed Tables.

Division of Albany.

The division of Albany possesses no Crown forests, properly so-called.

In terms of Section VIII, of the Crown Lands Act, No. 14 of 1878, and in all Government notices of the sale of lands under that Act, the lessee is prohibited from cutting any timber, trees, underwood, or bushwood, except such as shall be reasonably requisite for his personal use.

Precautionary measures.

It would be absolutely necessary to specify the portions furnished with timber, and to verify their actual state, in order to make certain that this condition is observed.

Creation of forests in this Division.

At the same time the question of introducing timber into these localities ought to be looked into.

Generally speaking, there is brushwood on the mountain sides although some of the hills are quite bare; but the summits of

the highest plateaux are absolutely destitute of timber of any kind; it is here, however, that trees would exercise the most salutary influence, and it appears certain they would succeed, judging by the splendid growths of the plantations around Grahamstown.

Grahamstown Plantations.

Maritime pine.

The maritime pine, especially, flourishes in a remarkable manner.

This species appears to accommodate itself with wonderful success to these dry and stony hill-sides, thrusting its roots into the fissures of the rocks, and developing into magnificent trees.

Division of King William's Town.

The Crown forests of King William's Town are situate at the north-west of the division, in the mountains of Pirie and Keiskama Hoek. They stand in a soil much less dry than that of the forests of Alexandria, and the trees attain very considerable dimensions. The species resemble more nearly those which compose the Knysna forests, but we saw no stinkwood or witte els.

Absence of stinkwood and witte els.

Yellow-wood used for sleepers.

Yellow-wood is much sought for. It is the only wood at present allowed to be supplied for railway sleepers.

The forests of this division have not been surveyed. Some licenses are granted for cutting timber and firewood, as also for taking saplings for the purpose of constructing huts and kraals.

Present supervision.

The staff charged with the administration of these forests is composed of Baron de Fin, Conservator, one head-ranger, and six subordinates. Correspondence with the chief office is conducted through the Civil Commissioner, who is called upon to give his advice upon forestry questions.

Objections to native rangers.

The Conservator states that the native rangers have not sufficient capability to perform the work which their duties demand. Their position among their tribes cannot fail to be a very delicate matter, when the interests of the forests are in opposition to those of their relations and friends, and especially when neither of them comprehends for a moment the utility of the measures which conflict with their interests.

Measures to be taken.

However this may be, the case is one pressing for attention, and particular heed should be paid to the following points:—

(1.) To accurately determine the situation of all Crown properties as fixed by law.

(2.) To draw up a valuation of the Crown forests, or, pending something better, at least an approximate one.

(3.) To take precautions against the danger of fire, such as are adopted in the Knysna, by keeping clear the borders of the forests.

(4.) To have rangers capable of preventing the young trees from being cut for the construction of huts and kraals.

(5.) To fix the seasons during which the various kinds of timber are fellable, and to disallow their being cut at any other, conformably to the Regulations of 1875.

(6.) To allow no herds or cattle to penetrate the forests, if it can be helped, or at least to prohibit their entering the districts where felling is taking place.

(7.) To watch carefully that the felling by contractors is not mixed with that of others who hold licenses.

Superior overseer recommended.

In this district, more particularly than for that of Alexandria, the supervision of a superior overseer would be necessary.

Such a task could hardly be imposed upon Baron de Fin, whose length of service, experience, and devotion, cannot be better utilized than at the locality itself of which he has the charge. It would be necessary to give him an assistant, who would fill the functions of second upper ranger for the portion of the forests nearest to Keiskama Hoek, now too far removed from the only existing head-ranger. This assistant should, at the same time, serve to ensure the carrying out of the forest regulations, and should also keep the books.

Above to be stationed at Keiskama Hoek.

Division of Stutterheim.

A ranger resides near Stutterheim. In approaching this town, it is perceived that timber becomes rarer and rarer. In the east of the division there is none existing.

Yield of forests.

The production of the forests managed by Baron de Fin, in 1880, was as follows:—

Timber ...	...	48,700 cubic feet.
Huts and kraals	...	184 loads.
Firewood	...	1,545 loads.

The total value amounted to £1,657.

The books of Baron de Fin, the Conservator, are very carefully kept.

Division of Queenstown.

From Stutterheim to Queenstown the country is absolutely devoid of timber.

Cathcart, plantations recommended at.

A sum of £500 should be devoted to plantations at Cathcart.

Creation of Crown forests.

There exist no Crown forests in the division of Queenstown, but the Government possesses about 30,000 morgen of Crown lands, of which the larger part could, without doubt, produce trees if works

for planting were carried out there. The soil has the reputation of being unusually fertile, and the scarcity of water is the only thing that the owners of the ground appear to dread.

Division of Stockenström.

The postal line from Queenstown to Fort Beaufort crosses the Crown forest of Katberg, in the division of Stockenström. The district through which this route winds is a steep mountain side, now desolated through having been burnt.

Effects of burnings.

Nature, alone, appears powerless to repair the waste occasioned. The land, still studded with trees, dry at their base, is overrun with bush and creepers, amongst which we could discover no natural sapling of a timber tree.

Here, as in the Division of King William's Town, the extent and contents, &c., of the forests have not been examined.

I drew the attention of the ranger, Mr. Atmore, to this absence of information on his part, and I showed him how he could determine approximately (until something better could be done) the extent and the value of the forests of which he has charge. He, with a zeal which I feel it my duty to record, explored the lots placed in his charge, and collected the particulars in the table annexed to this report, which show the apparent capability of the forests in the division of Stockenström.

Measures to be taken.

Undoubtedly, the first thing to be done on this point should be to define, as regards the Crown forests, the nature and extent of the rights reserved by the Government, and to decide as to how far it is practicable to enforce them.

Crown forests on native locations.

The Crown forests are spread amongst lands given as locations to the natives.

Reservations by Government, and extent of the obligations imposed by them.

The Act of Concession says: "The Government, reserving to itself all forest timber (if any), now growing, or being upon any part of the commonage of the location."

Does this reservation carry with it the obligation for the natives not to cut the young branches for their huts? Is there any obligation on their part not to allow their cattle to nibble the shoots?

Has Government power to sow or to plant in spaces devoid of trees, also in parts destroyed by fire; and to keep clear the borders of the forests in order to prevent fire, &c.?

These are all so many vital questions as regards the conservation of these woods.

Sneezewood has become very scarce.

We were told that a contractor had undertaken to supply 40,000 telegraph poles for a line beyond the colony. Is it expedient to exhaust our colonial forests for the sake of supplying to another State wood required for own needs?

Sneezewood: Contract for supply of telegraph poles to another State.

The superintendence of the forests in this division is entrusted to two rangers. The chief ranger has no superior chief upon forestry matters, other than the Commissioner of Crown lands. He is absolutely isolated in the country, without assistance, advice, or control.

Present supervision.

Can he anticipate eventual difficulties, or prevent that which is unavoidable?

Has he even sufficient preliminary ideas to enable him to grasp the origin of such questions, with their details and consequences? And to explain these points, and furnish useful advice upon them?

Necessity for experienced forestry officer.

In this district, as well as at Alexandria and King William's Town, the experience of a superior forestry officer would be indispensable.

Yield of forests.

This district produced in 1880 :—

Timber ...	...	70,000 cubic feet.
Firewood	...	72 loads.

The total value of its proceeds amounted to £1,271.

White ironwood.

The white ironwood is as much sought for as yellow-wood or assegai.

The particulars of these products are given in the Table below :—

Yellow-wood. Cubic feet.	Iron-wood. Cubic feet.	Assegai-wood. Cubic feet.	Red pear. Cubic feet.	Poles. Pieces.	Spar. Running feet.	Firewood. Loads.
13,500	15,800	17,200	7,200	3,277 cubic feet. 16,027	12,750	72

Division of Victoria East.

Tyumie forest.

In the division of Victoria East, bordering on that of Stockenström, is found the forest of Tyumie, adjoining those of the division of King William's Town.

Contract for yellow-wood sleepers.

A contractor is at present preparing sleepers there. The contract, to be executed during the years 1880 to 1885, is for the supply of 60,000

sleepers of yellow-wood. Ten thousand have been delivered, and 3,000 are prepared.

Dispute between native ranger and the Contractor.

At present there exists a difference of opinion between the native ranger, supervising the preparation, and the contractor, with regard to a lot finished.

The contractor has made, at his own expense, a road for getting out the timber from a mountain side, previously inaccessible, and the entire forest does not appear to contain much more yellow-wood than the quantity necessary for the execution of his contract.

In the meantime, other licenses are being issued, and the contractor does not fail to grumble sometimes, at seeing the road which he has opened used and worn out by other persons, for the purpose of carrying off trees upon which he himself had reckoned. Besides, the residents in the country see with anxiety all the timber of the forest disappear and carried off for sleepers.

The ranger is under the orders of the Civil Commissioner of Alice.

The forest of Tyumie is, for soil, temperature, contents, and the treatment it undergoes, in a position similar to that of neighbouring regions.

Private forests.

Between Seymour and Fort Beaufort we observed in the mountain, on the right, some private forests, and the forest of Mancazana on the left. The country is covered with massy *Acacia horrida*, improperly called here "Mimosa."

Fort Beaufort possesses some timber belonging to the Government. The Civil Commissioner issues licenses for felling, and his first clerk is deputed to measure it as it is cut.

"Yellow-wood" near Fort Beaufort.

Between Fort Beaufort and Bedford, we passed by Yellow-Wood, a place so called on account of the quantity of timber of this kind which was formerly found there. It is now remembered in name only.

On the north-west of Bedford, on the south side of the mountain, there is still to be seen the residue of a private forest; the timber which it contained has been almost entirely cut down. From Bedford to Graaff-Reinet, the thickets occupy fewer large surfaces, and the country becomes drier.

III.

Western Districts.

Western districts.

Nothing is comparable, however, in respect of dryness, to the district known as the Karoo, which extends southward of the line from Graaff-Reinet to Beaufort, West. There are no more mimosa thickets.

The Karoo.

The clumps of flowering shrubs, instead of forming green swards, are scattered far apart.

Saline eruptions, &c.

In a great many places saline eruptions appear on the surface of the soil, and we find much vegetable growth peculiar to the seashore.

Dryness of rivers.

The rivers overflow when it rains, and subside soon after, in such a manner that, during more than 300 days in the year, the beds are to be seen dried up.

Division of Beaufort, West.

Beaufort dam.

At Beaufort itself, the inconvenience of long intervals between the rainy days, has been remedied by the construction of a dam enclosing a large reservoir. By this arrangement, a large quantity of water, which would otherwise run uselessly to the sea, is shut up and stored for the use of the town for irrigation and other purposes.

Some plantations have been commenced here.

Experimental Garden at Beaufort, West. Mr. Clark's experience.

Mr. Clark, Superintendent of the Public Experimental Garden, thus describes his efforts :—

"I tried in vain for three years to grow some blue gums. This soil is brackish; the seed that I put in produced no results, and everyone here predicted that I would never raise a tree. I brought soils from neighbouring farms, tried them, and found some in which the seed produced very fine plants.

"I noticed that the brackish soil formed a superficial bed, not very deep, and by planting so that the trees had their roots below the saline layer, and by keeping them watered, the results, which are now seen, were obtained."

Success of Mr. Clark with blue gum trees.

We saw, in fact, very fine blue gums of two and a half years old, presenting every sign of a resplendent growth. It is truly fortunate for this district that the first attempts have been entrusted to an intelligent observer, who most earnestly desired to succeed in his work, and laboured with a perseverance that no discouragement could daunt.

Projected irrigation.

A reservoir is now about to be constructed, which will allow of an extent of 50 morgen being irrigated, on which plantations will be made.

Anticipated influence of plantation on climate.

It is to be hoped that these plantations will not be without exercising, ere long, some influence on the local climate.

However, I think that plantations of woodlands at a convenient height on the mountains in this region would be possible, and would have a beneficial effect.

From Beaufort to Cape Town the extensive plains of the Karoo are traversed.

The soil of this stony desert is generally of a faultless quality, and the country wants only a supply of moisture proportionate to its needs in order to become, without doubt, one of the most fertile tracts in the world.

Soil of the Karoo, its needs and its capabilities.

Next come the rich districts of Worcester, Wellington, and the Paarl, which would undoubtedly, however, gain much by the replanting of their hills.

Worcester, Wellington, and the Paarl.

Lastly, the Cape Flats are reached, vast sandy tracts, of which a considerable extent belongs to the Crown.

The Cape Flats.

I made a special visit to these lands on the 14th of September, accompanied by Mr. Lister, the Superintendent of Plantations.

Visit of inspection.

The Surveyor-General was also good enough to join us on the first visit, and gave me particulars of his personal experience of the place, so far as the necessities of his own duty had allowed him opportunities for collecting them.

The species of pines scattered in the district grow well in certain spots on the Flats. Near many dwellings, clusters of these old trees are to be seen, having attained a great height, and proportional size; and on the sides even of the railway we passed by young plantations in a good growing condition. On other parts of the Flats, they appear quite the reverse; they start, they vegetate during two or three years, attaining the second year less vigour than the first, and the third they fall into a state more or less sickly, until their weakness and decay is complete.

Success of pines in certain parts of Cape Flats.

Singular decay of them in others.

Sandy soil of the Flats, how fixed.

The Flats comprise shifting sands, and sands fixed by vegetable growth.

The plantations on the shifting sands were originally made by fixing in the ground lines of brushwood, and by sowing under the shelter of these bushes. In many places the success arrived at leaves much to be desired. The plan has been tried of utilizing the rubbish from the town, and by this means Mr. Lister has obtained very good results, especially in the valleys between the dunes, and better still around them.

Utilisation of Cape Town sweepings.

He uses generally the wattle (*Acacia falcata*) in these plantations.

Remarks on the wattle.

The bark of this tree is much in demand for tanning, and the wood itself furnishes good firewood, but it does not acquire dimensions suitable for timber purposes. This reason, as well as other points in connection with the cultivation of these trees, renders it desirable to supplement them with other kinds.

The blue gum has been tried, but without much success. Resinous trees, whose tough leaves offer a better resistance to the winds and to other accidents of climate, should be tried in preference, and there is every hope that some other species would accommodate themselves to the soil, judging by the spontaneous presence of *Sapree* wood in the midst of new plantations.

Species of trees most suitable for these Flats.

It would be well to analyse these sands as soon as possible, in order to ascertain their elements, and then further researches could be made.

Analysis of the sands of the Cape Flats.

Mr. Lister, the Superintendent of Plantations, has already fixed and planted about 400 morgen. He estimates the extent which remains to be fixed and planted at about 24 square miles.

Planting already done.

In 1881 he commenced to sell the products, the receipts for which during the year 1880-81 amounted to £381 3*s*. 6*d*., and he has hopes that they will increase yearly.

Receipts from Cape Flats in 1881.

The work of actively fixing these Flats should be continued, and thus enhance their value. Nothing could be more useful for the district, or present better chances of being productive. The manner in which these works have progressed under Mr. Lister's direction should inspire entire confidence in the ultimate success of the scheme.

Continuation and extension of the planting.

There exist no exact data of the extent of the Crown forests situate outside the district of the Knysna, but from what I have seen I am persuaded that the forests of the three divisions of George, in Knysna, and the Mossel Bay, represent very much in extent, and especially in material, more than half the resources of the colony. Until we obtain full information, we will assume that there should be 100,000 morgen of Crown forests, affording a productive material of 50,000,000 cubic feet, or say an annual yield of 600,000 cubic feet of timber of every kind.

Crown forests in George, Knysna, and Mossel Bay, extent of &c., annual yield and value, &c.

The stock of old trees of secondary species is less than 10,000,000 cubic feet.

Trees of secondary value.

It might be advantageous to use this superabundant material, the accumulations of centuries, and it is certainly necessary to free the forests of it, proceeding carefully, cautiously, and steadily.

Disposal of superfluous timber.

Treated in a reasonable manner, the Crown forests should produce, annually, at least 3,000,000 cubic feet of useful wood.

Annual yield of useful timber that should be available.

Private forests, attacked by the axe and fire, are on the road to a rapid detimbering. They do not cover more than 20,000 morgen, and they do not

Private forests, disappearance of.

contain timber to any appreciable quantity, except in those parts which have been recently sold.

Bush lands, extent and produce of.

The extent of bush land is even more uncertain. Regard being had to the positions they occupy, and referring to such information as I have gathered, I think that their extent may be estimated at nine times that of the forests, say 1,080,000 morgen. Thus 12,000 morgen producing timber, 1,080,000 morgen of brushwood, suitable for firewood, in all, say 1,200,000 morgen.*

Total yield of timber and firewood.

Besides the above, there are timber in certain kloofs in portions of the divisions of Namaqualand, Calvinia, and along the Orange river, described in the map of 1876, containing a large forest of aloe trees.

PART II.—*Requirements of the Colony.*

I.

CONSUMPTION.

Let us see now what are the requirements of the colony.

Consumption in 1880.

The total consumption of timber in 1880 amounted to—

"Colonial," approximately ...	250,000	cubic feet.
Entered for consumption ...	2,014,313	„
	2,264,313	„

Let us endeavour to summarise the needs that were satisfied.

In 1875 there were in the colony 55,212 houses.

Timber used for construction of buildings, &c.

Admitting that there are in it at present 60,000 houses, supposing a house to last fifty years, a number equal to 1,200 houses would be annually either entirely rebuilt or partially so; that is, reckoning 20 houses to each district.

If the average quantity of timber used in a house is 600 cubic feet, to meet this demand we should require 720,000 cubic feet.

The quantity employed in absolutely new constructions would be at least as large, and we should hope that it would rapidly increase, as this would be the most certain sign of the development of the country.

Total quantity used for construction of buildings, &c.

The consumption of timber used for construction may, I think, be estimated, in all, at 1,500,000 cubic feet.

In 1875 the colony possessed 421,762 draught cattle. Sup-

* From information which the Surveyor-General has been good enough to furnish, it appears there is a large tract of forest between the divisions of Uitenhage, Alexandria, and Somerset, known as the Addo Bush, but this tract is unsurveyed. Believed to be chiefly high bush and forests (unsurveyed), occupying a surface of about 100,000 morgen.

Unsurveyed forest lands.

Timber used in manufacture of vehicles, &c.

posing one wagon to require 16 of these animals, and deducting, say, 5,762 head, we should have, in round numbers, 26,000 wagons.

Besides oxen there were 235,000 horses and mules. Admitting that half of them would be employed for the saddle alone, and allowing for the remainder a vehicle for every four head, this would give 29,000 conveyances, into the construction of each of which there enters one-third of the wood necessary for building a wagon. We should, therefore, find employment for a quantity of material equivalent to that of 9,000 wagons; or, taken together, equivalent to 35,000 wagons. Allowing that a wagon is renewed entirely or partially every twenty years, the consumption is then represented by the quantity which would enter into the yearly construction of 1,700 wagons, say 170,000 cubic feet; and, reckoning waste, 200,000 cubic feet would be the bulk of timber consumed in this manufacture.

Total quantity used in manufacture of vehicles, &c.

For this purpose 1,700,000 cubic feet would be employed.

Balance of timber, how accounted for.

The remainder of 564,313 is doubtless used in the manufacture of furniture fustage, enclosures or fences, ship-building, &c., and employed by the Public Works Department in harbour works, ponts, sleepers, and telegraph poles.

Sleepers and telegraph poles; number cut in 1880.

In the year 1880 only 12,000 sleepers, and from 4,000 to 5,000 telegraph poles, were cut in the Crown forests, but these two products demand a special notice.

Sleepers for railways, present and future.

The construction of each mile of railway necessitates the use of 2,000 sleepers, including those requisite for shuntings and sidings.

There are open at present in the colony nearly 1,000 miles of railway, for the equipment of which 2,000,000 sleepers, equivalent to 4,000,000 cubic feet, are required. The life of these sleepers averages ten years.

The maintenance of the sections now open requires yearly 200,000 sleepers, equivalent to 400,000 cubic feet. The network of railways in the colony may possibly be extended by another 1,000 miles.

The construction of this extension will require 2,000,000 sleepers, equivalent to 4,000,000 cubic feet, exclusive of the wood required for railway buildings, station yards, and stores. The yearly maintenance of the new lines will absorb 200,000 sleepers, and the annual consumption will be raised to 400,000 sleepers, or 800,000 cubic feet.

The railways will, therefore, absorb—

For original equipment, 2,000,000 sleepers, or 4,000,000 cubic feet.

For annual maintenance, 400,000 sleepers, or 800,000 cubic feet. And, in view of this fact, the annual consumption of timber will be increased by 800,000 cubic feet.

As a matter of fact, the stage of maintenance has scarcely yet been arrived at; and, as I have previously stated, the quantity supplied during this year has reached the insignificant total of only 12,000 sleepers.

Sleeper contracts.

There are at present, to my knowledge, four contracts in operation for the supply of sleepers. They are being carried on in the forests of the divisions mentioned below, and are intended to supply the quantities indicated:—

Knysna	...	...	500,000
Do.	...	...	25,000
King William's Town		...	60,000
Victoria, East	...	...	60,000
Total	...	...	645,000

Telegraphs.

There are at present 3,140 miles of telegraph lines open. It is probable that the system will ultimately represent a development much more than double its present extent.

Poles for telegraph lines.

The poles necessary for the construction of the new lines, and for the maintenance of the entire system, will create a demand of very considerable magnitude.

Future annual consumption of timber for railway and telegraph lines.

The annual consumption of timber in the colony will then be certainly enlarged by a million cubic feet for these two services, and it is to be hoped that it will be augmented still more on account of the increasing development of the population.

Pecuniary saving, &c., in use of colonial timber for sleepers.

The manufacture of sleepers in the colonial forests represents a saving of at least six pence per sleeper; and an annual saving of 200,000 shillings, say £10,000, is not to be despised.

This saving will, I think, become much larger when we have made the necessary improvements. But even if there were no saving in the cost, we ought still to give the preference to the colonial productions, because their preparation, by giving employment to a large number of workmen, tends to the increase and well-being of the population of that portion of the colony.

Crown forests cannot supply present needs.

It is thus evident that the Crown forests, as at present worked, would be perfectly incapable of supplying the wants of the country, even with its present small population.

These needs are now partially satisfied by importation, but the eagerness with which stink wood is sought for proves that this species is not cultivated so much as it should be, and trade suffers by reason of its extreme scarcity. This is a state of things to be improved upon, because, where there are no reasons for restricting production in a district in order to grow something still more valuable, it is better to produce than to import.

Stink wood; supply and demand.

The production of this raw material at a rate cheaper than that at which it can be imported, would certainly be very beneficial to the trade of the country. An industry is often more seriously shackled than one thinks by the manufacturer not having at his door the raw material for the orders he receives; and it is always encouraged by facilitating the means of procuring the raw material.

Private forests not to be depended upon for supplies.

In the matter of forests we cannot rely upon the uncertain arrangements of private interests for the supply of our needs.

Reasons for above.

Again, into the production of timber there enters the element naturally vexatious in relation to supply and demand, namely, the question of *time*. Thus, in view of an order in hand for timber, where is there a speculator who would consider it worth his while to engage to execute an order deliverable within a century?

If the price of timber is low, it is to the owner's interest to clear his land for the purpose of substituting something that pays better. On the other hand, if the market is bare of timber, the price is consequently high, and he is then tempted to fell in a reckless manner.*

Ordinances against exterminating forests in France.

In order to preserve the forests [of France] a series of legislative enactments has been framed, which go as far as decreeing the penalty of death against those who grub up, without authority, even private forests.†

But laws against the extermination of forests have never proved effectual in preventing such operations when the owner found the latter to conduce to his advantage; and the long list of successive Royal Ordinances and Parliamentary Statutes starting from the time of Charlemagne, and coming down to the present day, has but served to exemplify the powerlessness of the law in this respect.‡

---

* In the plains of Languedoc, near the mountains of the Alps, the inhabitants grub up even the roots. It would be a good speculation to plant trees in those parts, but it would be fifteen or twenty years before any benefit would be derived from them, and life is too short.—G. HURIOT.

† Edict of Louis XV. against exterminators of forests.

‡ Clave, "Etudes sur l'economie forestiere."

Future potential yield of our Crown forests.

The improvements which the Crown forests of this colony admit of should raise their production of timber to the level of the present consumption, and increase it by well-conceived plantations, whose sites will not usurp the place of more important works, and will, at the same time, insure an increase of production commensurate with the augmented consumption which the future of the colony appears to promise.

II.

Influence of Forests on Climate.

Influence of forests on climate.

The observations which we have been bringing to notice, whatever may be their weight, do not touch upon the most important aspect of the question.

Timber is, doubtless, a primarily indispensable article; although when we do not produce it we can, as at present, procure it from elsewhere, not always, however, without some disadvantages; since when the time arrives that our stock of stinkwood or sneezewood is exhausted, and it becomes necessary to substitute for these woods imported oak or teak, the cost will be found very great. At any rate we could but partially substitute for it other kinds, and the industries which use the former would either perish or dwindle away.

Possible interruption of extra-colonial supplies.

Further, what would be the result if foreign complications arose to disturb the markets of supply? Or what would happen should the ocean transport be interrupted?

We will proceed, however, to the main point.

Storage of rainfall.

The colony possesses very extensive territories, which require an enormous annual rainfall.

It is, in the highest degree, requisite that the rains, instead of collecting instantaneously on their way to the sea during the twenty-four or forty-eight hours succeeding their fall, should be intercepted, in order to preserve the coolness of the soil for as long a time as possible; and that they should be absorbed to enable them to re-appear afterwards, at various spots, in the form of perpetually-flowing streams.

Partial destruction of forests in France, and its results.

Now forests do unquestionably exert considerable influence upon the climate, and upon the conditions of the water-supply of a country. Up to the year 1865, we have been dwelling upon, as a whole, the climatic and hydrological facts which followed upon the destruction of the forests—facts proved in every country of the world as yielding a sufficient explanation of those phenomena. At this period, however, the French Government proposed to alienate a portion of the State forests in

order to apply the products of the sales to the execution of works of public utility. It proposed, in a word, to substitute for forests, canals, roads, and railways. What prospect could be more enticing to the public?

However, the *savants* remember the consequences of the destruction of the forests.*

The Government then tried to find other causes for the effects indicated, and endeavoured to remove from the forests the stigma attached to them on account of these phenomena. But the great majority of the *savants* did not find these explanations tenable, and preferred to wait longer for the realization of their ardent desires than, by killing the goose for the sake of the golden eggs, to risk the fertility of the country in order to obtain these benefits as soon as possible. The field was thus opened to scientific research on the subject. Observing stations were established, at which the results of the examinations were analysed and investigated; so that there are now the elements for establishing, in a synthetical manner, that which could be given, at the time when the subject was mooted, as only a proof by induction.

Establishment of observing stations in the French forests.

Explanation of action of forests.

The following is a *résumé* of the data collected:—

1. A comparison of the various thermometrical observations shows that the temperature of a given district is lower within than around the forest. This difference, almost *nil* in winter, is raised more than five degrees in summer. During the hottest season of the year the moisture from the forests ascends to the air-currents above them. These currents cause the temperature to be lower than is the case in connection with those hovering at the same height, above portions of the soil that are not wooded.

Thermometrical observations.

2. Hygrometric observations prove that in forests, in their vicinity, and principally above them, the atmosphere is more charged with moisture than it is in districts removed from them, all other circumstances being otherwise equal. M. Tissandier discovered, during an aerostatic voyage, that when the balloon was travelling over a forest the hygrometer rose with extreme rapidity, but descended as soon as the forest was passed.†

Hygrometrical observations.

3. Observations of the rain-gauge prove—

Raingauge observations.

(*a.*) That there falls in forests, and within the radius of their influence, a larger quantity of rain than on similar districts deprived of timber.

---

* M. Becquerel, among others, in his report of the proceedings of the "Academie des Sciences," at its meeting of 22nd May, 1865.

† "Academie des Sciences," 10th October, 1880.

(*b.*) That the higher the situation of the woods the more sensibly is this influence felt.

(*c.*) That the foliage of trees intercepts an amount of rain varying from 8·5 to 52 per cent.

Atmometric observations.

4. Atmometric observations prove that evaporation is from six to seven times less within the forests than beyond them, and three times less from parts surrounded by wood than from ground absolutely open. Evaporation from agricultural soils is at least 70 per cent. of the amount of rain received by them.

Humus, or mould and its absorbing powers.

5. There is found in forests, under a bed of dead leaves not yet decayed, a layer of *humus*, or mould, formed by the decomposition of the leaves and the crushed vegetable matter previously accumulated and already rotting in the soil. The property of absorption possessed by this *humus* is about eight times greater than that of the various* limy soils, and from 2½ to 5 times greater than that of the different clayey soils.† The presence of mould on a soil, combined with the action of the roots of trees, augments the permeability of underlying strata, the least favoured in this respect.

Forests prevent gathering of torrents.

6. Forests, by reason of the rains which they attract, prevent the sudden gathering of rushing torrents.

It therefore follows:—

Effects of the action of forests.

That forests are vast condensing apparatuses, favouring or inducing the formation of rain and dew.

This influence of the forests was known long before any one had dreamt of determining it by natural experiment.

We shall proceed to cite in support of this assertion certain facts proved no less in the colonial territory than in the countries which most nearly resemble it in all geographical respects.

Proofs of the above.

Cape Colony.—"He" (Conservator of Crown forests at the Knysna) "mentions that during the severe drought in 1873 both the Tzitzikama and Knysna forests were visited by frequent showers, which rarely travelled beyond the forests."

Cape Colony.

"The immunity which British Kaffraria enjoys from the droughts so common in South Africa is believed to be due to the influence of the forests."

Natal.—"As regards the meteorological influence of forests, the heavy timber lands have been observed to be the great condensers of vapour."

Natal.

* Calcareous.

† According to Schubler and Boussingault.

Mauritius.—"It is pretty generally believed that the destruction of the forests has had considerable effects upon the climate, and that, owing to the same cause, the floods are much more sudden and destructive than formerly. Many streams which never failed whilst their sources were shaded by the forests are now dried up."

Mauritius.

St. Helena.—"St. Helena seems to afford a somewhat striking example of the effect of forests denudation upon climate. It is stated that the extirpation of the indigenous trees, shortly after the first colonization of the island in 1673, was followed by a succession of severe and destructive droughts, but that since the forest lands were replanted, the island has ceased to suffer from them to anything like the same extent."*

St. Helena.

Among a thousand other historical facts we will mention ths following:—The dryness of the climate of Egypt is such that it never rains in Upper Egypt; and in the Delta, in former times, not more than five or six days of rain annually could be depended upon. The Viceroy, Mehemet Ali, planted, at one period, 20,000,000 of trees on this same delta. Some years after, when these trees had grown lofty, the number of rainy days increased to 45 or 46 annually.†

Egypt: rainfall induced by planting trees.

As wooded soils absorb more water than others do, the presence of forests must exercise a considerable influence on springs. Instances of this influence recur perpetually.

Springs influenced by forests.

For example, the water source of the island of Ascension was exhausted by reason of detimbering, but the water returned when the mountain was replanted.

At Ascension.

Mr. Bean, Engineer of the Grande Combe, has established the following facts: The Company to which he was attached planted a forest of 850 hectares (about 1,000 morgen), and as soon as a portion of the plantation became advanced enough to deserve the title of "a wood," an old spring, which formerly with difficulty supplied in the heat of summer, two steam engines, yielded sufficient to feed these two engines, while its working power was more than doubled.

At the Grande Combe.

In the second place, the streams of this basin, during heavy rains, are not subject to such constant and violent floods as before, and the water runs slower and *for a much longer time.*

3. Forests, whether by influencing the number of days of rain, or by retaining rains for a longer period in the regions which receive them, or by favouring the feeding of springs,

* Analysis of returns in reply to queries relating to Colonial Timber, 1878, pp. 8, 9, 21, 37.

† Report on Rains and Forests, 1868.—Evidence of M. Pouchet.

and probably by exercising these reciprocal functions, have a marked and beneficial influence upon the rainfall of a country, and consequently upon its fertility.

In this regard, coincident facts are still more numerous.*

We will cite the most recent and the most common.

Forest influence on the waters of Lake Tagarigua.

The rivers which water the valley of Aragua, in the province of Venezuela, form, in their confluence, the Lake of Tagarigua, and have no other outlet. Humboldt, when visiting that country at the commencement of this century, ascertained that there was a gradual subsidence of the water-level of the lake. When, in 1822, Boussingault explored the country, he learned that the water had risen considerably. The forests had taken possession, during the same period, of a large tract of country in which the population had been decimated by the war of independence. They had developed there with that wonderful activity of vegetation which characterises the growth of trees under a tropical sun; and the rise of the water corresponded with the retimbering of the basin.

Subsidence of water-level of German rivers owing to disafforesting.

From a communication made by M. Counsellor Wex to the Geographical Society of Vienna, it appears that, since the extensive detimbering which has taken place during a period of fifty years, the mean level of the Elbe has fallen 17 inches; that of the Oder 17 inches; that of the Rhine 24 inches; that of the Vistula 26 inches; and finally, that of the Danube, at Orsova, 55 inches. At the same time a very sensible diminution of all sources of supply was found to have occurred.

Austrian Hydrotechnical Commission's reasons for the above.

The Hydrotechnical Commission appointed by the Austrian Engineers, for the purpose of examining into these facts, was unanimous in declaring that *the primary cause of the very disastrous decrease of the waters is due to the devastation of the forests.*†

Khanate of Bokhara made arid through disafforesting.

Twenty years ago the Khanate of Bokhara was one of the most fertile regions in Asia. This well-wooded and well-watered country, nourished by numerous streams, was a veritable terrestrial paradise. During the last 25 years all the woods have been cut down, and the few trees which remained were consumed by fire during a civil war. It was not long before the consequences began to be felt. The result was the complete transformation of the country into an arid desert. The streams dried up; the canals, excavated in olden times for irrigation purposes, are perfectly empty. The shifting sands of the desert, being no longer held in check by the barriers

* Becquerel on Forests and their Influence on Climates.

† Report on Rivers and Forests, 1875, p. 280.

formed by the forests, are gaining on the soil every day, and will eventually invade the Khanate in every direction, and transform it into a desert as arid as that which now divides it from Khiva.*

Humboldt on consequences of disafforesting.

This example entirely justifies the weighty words of the illustrious Humboldt—

"By felling trees which are adapted to the soil of the sides and summits of mountains, men, *in every climate*, prepare for future generations two calamities at once—want of firewood and scarcity of water."

Forest influence on torrents and on mountain sides.

4. Forests exercise an important influence upon torrents of water,

They preserve the soil on the mountain sides by maintaining the vegetation, and they protect the beds of large rivers from the encroachments or silting up which obstruct the mouths of those rivers. These facts have never been disputed. The results of twenty years of labour, crowned with constant success, confirm them to-day.

Forest influence on river beds and embouchures.

(*To be continued.*)

Mochras—an exudation from the bark of Bombax *malabaricum*.

DEAR SIR,—An inquiry was some few years ago set on foot by the India Museum regarding this substance, which is very curious. I collected specimens and sent them with a long note to Dr. Cooke, but have since heard nothing further on the subject.

The drug collections in the Panjab Exhibition of 1864, and also many local lists of drugs, gums, &c., contained entries of "mochras" (variously written mūcharas, mocherus, mocheras, &c.) The question was, what was the origin, nature, and use of the substance. It was confused (or identified) in *some cases* with what was called "phūl-supyárí" (=flower of the areca palm) though this was not a flower but a brown dry leathery kind of blister. But evidently the common mochras was not the product of the areca palm, which is unknown in the Panjab. This however would not be conclusive, because the substance may be imported. Will some officer in BENGAL or BURMA kindly enquire whether the areca palm yields any *gall* or astringent *gum*, or even an astringent *flower-bud?*

"Mochras" was usually assigned to the sembal tree (*Bombax malabaricum*) as its origin. In appearance it is what I have described, pieces of dry leathery but rather brittle, dark brown

* Report on Woods and Forests, 1876, p. 93.

substance, looking exactly as if a hollow blister of some material had formed on the surface of the bark, had dried there, and been broken off.

In my garden at Lahore there are two large and well grown Bombax trees, which must be as old as the very earliest British resident who came to Lahore, if not earlier. They are certainly planted, because though they do well in the good sailaba soil, they are not indigenous to the soil within a few miles of the river Ravi. I detached bits of the bark from one of these trees, made incisions, cut into the surface only, and down to the sapwood, and into the sapwood, but no gum or any other exudation of any kind appeared. But the other tree, which divides into two stems at about eight or ten feet from the ground, is covered, as to its lower part, with a clustering mass of the lovely "pink coral creeper" (*Antigonum leptopus*). Having occasion to trim this, and remove the old dry stems or bine, I disclosed the surface of the tree, and saw that close to the fork of the two branches, the stem was somewhat swelled, the bark was all broken up and excoriated, as if in fact a large sort of unhealthy swelling sore was there: a mass of brownish or blackish powder, or rather friable grains, had also fallen and collected at the foot of the tree. This residue looked rather like the excreta of some insects boring into the bark, but I could not detect any trace whatever of any bark-eating insects, or any *aphides*, &c. A great deal of this powdery stuff was to be brushed off the wood itself, seeming to come from the disintegration of the bark over the "sore." From all parts of this sore I found great masses of the "mochras" which had exuded and dried there; much of it was old and partly rotten, but some that was fresh looked like deep brown bubbles or shells that had irregularly contracted in drying. I cleared away all the powder, and picking of the best bits of mochras to go to Dr. Cooke, I cleared away the old rotten stuff. After some days I observed new mochras form; to my surprise it issued in various shaped masses, or worm-like pieces, as if one squeezed oil paint out of a tube; this gradually curled up or coagulated into a mass as chance would have it. It consisted of a rather firm slightly translucent dirty whitish yellow jelly.

To the taste it was almost insipid, but with a slight roughness indicating astringency. It proved wholly insoluble in cold water, and nearly so in boiling water, though I think it went into a pulp under such treatment. It did not appear either, soluble in pure spirits of wine, but imparted a red color to the liquid.

This jelly, when dried by the air and heat of the sun, acquired a dark brown color; the surface dried first, and the inner part gradually shrunk afterwards, accounting for the blister-like irregular pieces. This then is mochras (at least one kind of it).

But what is its nature, and under what causation is it produced? It seems to be of no use except for its astringent property, the native drug collectors having taken it as a "gall" (which it is not.)*

Perhaps some of your readers can add to our information about this substance, and also clear up the question what is phūl-supyárí of the areca palm?

The native writers evidently confuse the two things, because the author of the "Makhzan-ul-adwiya" says that mochras is the bud of the *areca palm*, but Hakim Ahsan Alí says that it is the exudation of sembal (*Bombax*.)

From Gurgaon I also obtained "phūl-supyárí" just like my "mochras," and the druggist declared they were one and the same thing; but still as a local druggist of Delhi insisted that he got *his* mochras from "purb" (Bengal, the East generally), and that it is the product of the areca palm.

The native druggists also confuse mochras with the gum of of sohájna (*Moringa pterygosperma*) which is a red astringent gum, but this mistake leads to no difficulty.

It is also curious that when I showed my *Bombax* mochras to druggists of Lahore, they said that was not real "mochras," though beyond all question it was absolutely identical with specimens in the exhibition sent as mochras, and also with some sent as "phūl-supyárí." *Their* idea of "mochras" was a red gum like that of *Moringa*.

Yours truly,

B. H. Baden-Powell, C.S.

Effects of Forest fires on reproduction in Teak Forests.

We have received a note from "J. N." on the cause of hollowness in mature teak trees, which we regret to be unable to print in its entirety. After noting the great number of teak trees in Burmah which, to all appearances sound, are found to be hollow owing to the former prevalence of jungle fires, he suggests that fires by attacking the close tough felty covering round the seed prepare it for germination; and he proposes that failures in sowing, which have been repeated twice in

five years in the Tharawaddy and Prome districts, might be avoided by mixing the seed with dry grass just before the rains, and burning it rapidly in imitation of the former usual conditions, and thus a year's delay might be saved. We may add that a system, similar to the one here proposed, used to be, if it is not still, followed in the Bombay Presidency. The seed was sown thickly in a bed in the hot weather, and covered over with grass and straw, which was watered copiously up to just before the burst of the south-west monsoon. After the watering was stopped, the half decomposed covering was fired, and it was found that the first heavy shower of rain brought up a good crop of seedlings.

"J. N." also raises a question which we put in his own words :—

"Will teak, unless special measures be taken for the subordination of other kinds of trees, continue to assert itself within fire traced reserves; or is it likely to be overpowered by genera of trees better able to stand shade in their youth, and whose seed germinates more rapidly than teak-seed? The fact of teak being a light-loving tree is indisputable. It nowhere forms pure natural forests except on low knolls adjacent to paddy fields—sites over which the jungle fires annually pass with unfailing regularity. But in fire protected reserves these circumstances, on the whole so favourable to teak, are precisely those to which the whole system of fire protection is diametrically opposed."

We could reply to this question at once, but the answer would be a long one, and must be postponed until another opportunity.

Cuttings from Eucalyptus globulus.

SIR,—I have never heard of any one making cuttings of *E. globulus*, although the practice is perhaps extremely common. So I write to tell you of my success in growing, transplanting, and putting out cuttings in the Himalayas at an altitude of 6,700 feet.

I obtained a large packet containing some 16 species of *Eucalyptus* from a Vienna firm in March 1881. I sowed all the seeds in my garden in rows about 1½ feet apart during May. The position was most unfortunately chosen, as my garden is on a ridge, and every day I am treated to a strong wind from the south-west which commences at noon and lasts till sunset. By July the seeds only of *globulus*, *resinifera*, and another species had germinated; all the rest had failed utterly. In October I transplanted all the weaker and smaller *E. globulus* plants, now about ten inches high. In December I covered them all over with grass to protect them from the snow. On my return from the plains in April I found the transplants had outgrown

the plants left in the nursery, and were now two feet six inches high. With the return of warm weather all the plants made astonishing progress, so much so that the branches were getting too heavy for the parent stock. I cut off all the lower ones, and my gardener stuck them into the ground in rows. To my delight, after the lapse of a fortnight, I noticed that the cuttings were putting out tiny leaves. This decided me to try the effect of transplanting the trees remaining in the nursery, now grown some six feet, and also the last year's transplants, which were even higher. I took them all out during a heavy rain, and planted them on the north-east side of the ridge so as to protect them from the wind. For a few days they all looked very sickly, but now they are growing rapidly. The conclusion I have come to is that the *globulus* is like the Pansy —"the more you transplant him the better he is." Now for the *resinifera*. This is a grovelling sort of plant; at least I can't induce mine to grow up. It prefers lying prone, although, when stretched out, the biggest plant is over five feet high. Strange to say the stem is thicker than any of the *globulus*. Has the Forest Department succeeded with larch? Last year I had a bagful of seed fresh from England given me. I sowed the seed in every likely and unlikely way, in all manner of soils, and in all months, commencing from April and ending in October, but I have had no success whatever. What is the Scotch method of sowing the seed? The hazel I got from England is succeeding admirably (there is any amount growing wild in the Kernaithi forest between Narkanda and Kotgbur, but the nut is worthless). My gorse too has had the effect of putting the langúrs to flight when they attempted the passage to my garden. I want now some Spanish chestnut; it ought to succeed well.

MUNDI STATE. RIVERINE.

[The larch seed was probably bad, or was sown too deep. If the soil be sufficiently friable, and the seed be good, and only just covered with soil, there should be no difficulty about its germination, but *vide* Brandis' Forest Flora, p. 532, where it is stated that all attempts to grow larch in N. W. Himalaya have failed.—ED].

The Man-eating Tiger of Garhwal.

In the spring of 1881 the celebrated man-eating tiger of Kalagarh and Saneh in Garhwal was feared far and wide, and when I was encamped at Kohtri, in the Kohtri Dún, a party of Goorkhas from Almorah came down to Kalagarh on the Ramganga river to shoot this tiger. He had, apparently, made Kalagarh his head-quarters, and his "beat," it was said, included all the hilly country within a radius of 50 miles northward of Kalagarh. Several attempts had previously been made to kill him, but all without success. The Goorkhas established themselves at Kalagarh fully determined to rid the country of this terrible pest, but unfortunately they did not, I was told, go the right way to work. Instead of endeavouring, systematically, to track or mark down the tiger in a manner calculated to alarm him as little as possible, they went in for indiscriminate slaughter, shooting at everything within reach. The consequence was that Stripes took alarm at the unusual noise going on, and, thinking discretion the better part of valour, quietly, and without giving any notice of his intentions, left that part of the country. He travelled along the watershed, which, beginning near Kalagarh, runs almost due north-west, and terminates near Kohtri, and came to a halt at its foot, about half a mile from my camp. There were at that time a large number of bamboo-cutters in the Dún, and these men were in the habit of wandering fearlessly about the hills, a man-eating tiger never having been heard of in that part of the country.

One morning five of these men went up the hill side, as usual, to cut bamboos and grass; one of the five, thinking he would find these products more plentiful a little further up, left the others, and continued his walk up the hill, having previously asked the others to give him a call when going home. In the afternoon, however, when they called for him he was not to be found. A search was made till nightfall, and continued again next day, but without success. In the afternoon of the second day these men came to my camp, and reported to me what had happened. I immediately came to the conclusion that the missing man had either fallen down a precipice, or had been mauled by a bear! I got together my own establishment, and as many bamboo-cutters as I could find, and sent them all up the hill side to search the place carefully, while I, on an elephant, beat up all the high grass in the vicinity. This was kept up till dusk, but no sign of the missing man could be found.

Next morning, the third day, I was marching down the road to Saneh. When I had got about two miles down the road I met a boy with some buffaloes hurrying up the road. He told me that in a sot, or deep gully, not half a mile from

where we were, there was a tiger who had charged them, and driven them away when they went there that morning to collect their bamboos, and that the tiger appeared to be eating something. He told me an elephant might easily be taken up the sot, and he offered to guide me to the spot. When I had proceeded some distance I came to a piece of ground which I thought was a little too steep for an elephant; moreover, judging by the look of the ground ahead, I thought that I should gain no advantage, even if I did take the elephant further up. I, therefore, dismounted, and taking a rifle and the *mahout* with me I followed the guide up the hill side. I told the latter to warn me when we approached the spot. I had not the least intention of attempting to shoot the tiger on foot! I went up only to reconnoitre, and to find out if it were possible by making a "*detour*" to take the elephant up there if I thought it worth while doing so; or if there was any likelihood of my being able to bag him by sitting up on a tree over the kill. We walked on for some time up a spur with a deep precipice on the right, and a small stream in gently sloping ground on the left. The ground on the left was covered with dense scrub jungle and bamboos, and a few scattered trees of dhaora, bhalao and sal. I was busy noting this when the guide suddenly stopped, and, pointing to a spot not more than four or five yards off, said: "This is where we were standing, and that is where the tiger was lying." The *mahout* then picked up a piece of bamboo, and throwing it into the little *ravine* to our left said: "Is *that* where the tiger was?" Before the guide had time to reply we heard a low growl. I immediately seized my rifle, and began to look about for a safe spot to retreat to! In the meantime a continuous growling was kept up, but I could not possibly tell where it came from. At one moment it appeared to come from the ravine at my feet; the next moment it sounded as if several yards away. The guide said it came from above, the *mahout* said it was below, and I thought it was in the ravine at our feet. This went on for some time, probably a minute (to me it appeared very much longer!) I then asked the *mahout* if he could bring the elephant up, and on his saying he could do so, I climbed up a tree, and sent the two men down. I noticed that while I was climbing the tree the growling ceased. The tiger, I thought, has either gone, or is preparing to attack us! I scrambled for a seat, took the rifle as quickly as possible, and sent the men the shortest cut down the hill, and in the direction opposite to that in which the tiger was. While the men were away I carefully watched every inch I could see of the ground in the hope that I might get a shot at the beast. When the elephant came up I got into the howdah from the branch on which I was seated, and went straight into the jungle. When there I found that there was a second ravine

about 10 or 12 yards beyond the one near which I had been standing. The elephant gave unmistakable signs of the presence of the tiger, and I expected every moment to put him up: but he had gone. I beat up all the grass, and then turned to go down again, when the man I had behind me in the howdah drew my attention to something black, which was just visible in the grass. I took the elephant up to this object, but I couldn't tell, even with the aid of a pair of binoculars, what it was. After a great deal of coaxing I succeeded in persuading the man behind me to get down. He cautiously approached this black object, and then in a tone of great relief said: "Oh! this is the head of a man!" I only then became aware that I had been in the presence of *the* man-eater, and fully realized the extent of the danger I had been in; for this tiger had, on more than one occasion, dashed into the midst of a gang of men, and killed two or three of them. The thought of what *might* have happened sent a cold shudder through me, and I felt truly thankful that I had got off safely. Had he charged us I could hardly have done him much harm under the circumstances.

I carried the head down with me, and it was identified by the bamboo-cutters as that of the unfortunate man who had disappeared three days previously. I then sent it on to the thanadar at Kohdwara.

The Goorkhas at Kalagarh shot a tiger, but it was not the man-eater, as was proved by the number of men killed subsequently at Saneh.

They nevertheless received the reward (I believe Rs. 500) that had been sanctioned for the destruction of the tiger, as it was very difficult to prove at the time that the tiger shot by them was not the right one, especially as the Goorkhas asserted that they had found some human remains in the animal's stomach. Sir Henry Ramsay therefore determined to give the men the benefit of the doubt.

There is, however, one fact which may perhaps go towards establishing the identity of the Saneh and Kalagarh tigers. It is that the Kalagarh tiger from the shape of his pug was known to be club-footed, and when the tiger shot by the Goorkhas of Dehra was examined, it was found to be defective in the first two toes of one of the fore-paws, these two toes having withered away from the effects of a wound it had received.

The terror inspired by the presence of this tiger was so great that the forest was at length deserted. He was always on the watch. Seated on a commanding spot he used to wait for the first sound of an axe, and then skilfully stalk and pounce upon the unfortunate individual using it. This became so bad that the bamboo-cutters deserted that part of the country, the forest produce remained untouched, and the revenue fell in consequence.

The Inspector-General of Forests, therefore, deputed Mr. Dansey to shoot this tiger, but unfortunately he was recalled before he had quite completed his arrangements.

The honor of shooting the "man-eating tiger of Garhwal" fell to the lot of a small band of plucky little Goorkhas from the regiment at Dehra. These men tracked the tiger into a narrow sot near Saneh, and "tossed up" to decide as to which of them should lead. They came upon him suddenly, fired *a volley, and dropped him. Thus fell this formidable beast* who for years had been the terror of all the unfortunate bamboo-cutters in the Patli Dún, and its vicinity. All the attempts made by the officers of the Forest Department, and by shikaris to shoot him or to poison him, had failed; and the little Goorkhas carried off the reward that had been offered for his destruction.

I believe that in this case too the reward was Rs. 500. There is a general belief that the skin of a man-eating tiger is mangy. The skin of this particular tiger is now I believe in the possession of Mr. Parker, District Superintendent of Police, Saharunpore, and I am assured by a gentleman, who has seen it, that it is a very fine skin with a thick glossy coat.

It is supposed that a tiger turns "man-eater" only when, owing either to a wound received or to old age, he becomes incapacitated from running down his natural prey. This may be true in some cases, but is not I believe a generally established fact, as instances have been known in which neither of these conditions existed.

L. E.

Teak.

I.—Geographical Distribution.—In Coorg teak grows in a zone of from two to six miles in breadth along the eastern boundary, at a rough calculation 40 square miles, mixed with other deciduous trees, such as *Terminalia tomentosa*, *Pterocarpus marsupium*, *Dalbergia latifolia*, and *Anogeissus latifolia*.

It is also found occasionally in clumps at the bottom of the Western Ghauts.

II.—Requirements as to :—

(*a.*) *Climate.*—The temperature of the deciduous forest ranges between 56° and 96°, seldom below or above these limits. Teak is seldom seen in Coorg above the altitude of 3,000 feet.

Moisture.—Teak does not attain large dimensions with a rainfall of less than 45 inches, but we have no certain data as yet. With a small rainfall the tree grows stunted. At the bottom of the Ghauts it flourishes and makes rapid growth with a heavy rainfall, probably 200 inches. About two-thirds of the rainfall is from the south-west monsoon from the 15th June to the 15th September, and the rest from the north-east monsoon from the 15th October till the end of November. In March, April and May there are occasional thunder showers. February, March, and April are usually hot and dry.

(*b.*) The *soil* should be a rather stiff loam, must be of good depth and fairly well drained, but at the same time capable of retaining some moisture. It does not object to ferruginous soil, nor to a moderate proportion of stones, and from the frequent presence of lumps of lime found in Coorg teak wood it may be inferred the soil is often calcareous, and not exactly congenial to teak. In the deciduous forests the upper layer of soil, varying from 9 to 18 inches in depth, is a black vegetable soil. This layer of soil is extremely rich. It is friable and easily worked. Beneath is generally a stiffish loam several yards deep, light brown and sometimes yellow in colour. The underlying rock, which is very rarely seen in these forests, is generally gneiss.

(*c.*) *Locality.*—As already stated teak is not found often above an altitude of 3,000 feet ; the deciduous forests of Coorg and of Mysore are from 2,500 to 3,000 feet above sea level. It grows equally well in all aspects. It prefers a gentle gradient, such as will carry off the water, but does not like steep land. Thus it grows best in undulating country with low rounded hillocks.

Below the Ghauts it is found on well-drained rounded knolls and spurs.

III.—Dimensions.—The average height and girth attained in Coorg is 8 and 80 feet respectively, but the girth measurement in the south-eastern forest, in which grow the finest teak, is often much exceeded. A few trees there measure as much as 15 feet in girth. They are old trees which we have

at present no means of turning to profit owing to their great size. The maximum height is about 120 feet. Below the Ghauts it does not grow to a great height, but is generally stunted owing to its exposed position, but the boles attain a large size.

IV.—HABIT.—The ramification is diffuse, the branches nearly at right angles to the stem. The foliage is light letting through light and sunshine. The crown is egg-shaped in a solitary tree, occupying about three-fourths of the tree's height. In the forest it occupies from half to two-thirds of the tree's height. The length of the bole of a tree in the open is about 15 feet; in the forest about 30 feet.

V.—TEAK CANNOT THRIVE UNDER COVER.—It will exist but will make no growth; it gets bent and lanky; but with its leading shoot free it will grow and flourish. Teak rarely pierces through cover unless it is very light. Even under teak cover, itself very light, young teak does not thrive. In some portions of the Coorg forests, which were very badly treated before the establishment of the Forest Department, and in which teak was cut out recklessly, neither teak seedling nor coppice have been able to grow owing to the bamboo cover. But young plants will exist for years under cover, hardly making any growth, and will recover when disembarrassed.

It objects to interlace its branches, and its head becomes contracted by contact with other trees.

VI.—PERSISTENCE OF LEAVES.—The leaves fall in February and begin to reappear soon after the jungle fires, and the trees get their full foliage by the middle of June.

VII. TEAK BECOMES FERTILE AT BETWEEN 20 TO 30 YEARS in plantations, often much sooner. But seed should be chosen from trees 50 to 60 years old. It flowers in June and July, and the seed ripens in March. The seeding is annual, but in favourable years it is much more prolific than in others. An early monsoon, such as that of 1879, which commenced in Coorg with a heavy burst on the 28th May, destroys a great part of the blossom. A very light monsoon, like that of 1877, is also unfavourable to the seeding. The seed has considerable vitality, and could probably be kept several years without losing it. Seed sown in the ground, which has failed to germinate in the first year, will often do so in the second. It is frequently destroyed by insects, which bore into the outer covering when it is young and soft and eat the kernel.

VIII.—TEAK SEED IS NOT EASY OF GERMINATION.—For cultural purposes it is soaked for 48 hours in water before it is sown, in order to soften the hard shell in which the small kernel is contained. In nurseries, unless the seed has been very well chosen, a very small proportion of the seed put down germinates, because a large proportion is pierced by insects and loses its vitality. It is believed that this pierced seed has a tendency to fall from the tree sooner than the healthy seed,

and on this account we always try to get our nursery seed gathered from the tree itself, not collected under the tree.

In the forest young plants are not seen unless there is an entire absence of cover—not even under the light cover of old teak foliage. On the other hand in open spaces a number of seedlings will frequently be seen.

There is some reason to believe that jungle fires aid the germination of teak. It is very possible that the charring of the outer shell may help germination. Also the destruction of underwood will let in the necessary light and air without which the young plant would not persist. On the other hand the fires must destroy annually a large quantity of teak seeds.

IX.—TEAK SHOOTS EASILY FROM THE STOOL and will do so under favourable conditions up to a great age. Stools of trees 250 years old, and of even older trees, will sometimes coppice.

X.—AS REGARDS THE RAPIDITY OF GROWTH in the small plantations in Coorg plants grow to a height of 35 feet and 1 foot 6 inch in girth in 10 years. There would be presumably a similar growth under favourable conditions in the forest.

In the latter case, however, they are often dominated by short-lived soft-wood, such as *Kydia calycina* and *Grewia tiliæfolia*, and simply hold on to life, making very trifling growth until room is made for it by one of the dominant trees succumbing. In other cases the plant gets continually burnt down until a shoot of sufficient height and strength is produced to defy the fires. This then makes rapid growth, unless it gets covered up by soft-woods.

Ring counting on stools of trees in the forest give most variable results. We find trees, after growing very slowly for 150 years, will suddenly put out great vigour and add an inch of growth in eight years— the same individual at 50 years having only been able to make an inch in 20 years.

In the accompanying table No. 6 stump shews 28 rings to the second inch, shewing that it was long dominated in its youth.

Judging from the ring countings which have been made in the Nalkery forest, the best teak forest in Coorg, it must take 250 years to make a first-class sized tree 6 feet in girth at 5 feet from the ground. In a plantation, the same size would probably be attained at little more than half the age, or say 150 years. In the plantations in the hot steamy climate of Nilambur, this size will, judging from the growth, hitherto be attained at the age of 80 to 90 years.

It is burnt down when young by forest fires, often year after year, only to send up a stronger shoot each time, till at last it gets above the fire's reach. After this it is little affected by them, until they pass their maturity, when the fires gradually eat into them at the bottom, but so gradually that as a rule the tree at length succumbs to decay from the top. Insects sometimes attack the young branches of teak plants raising

wooded rings on them, making them look as if strung with big beads; two or three such are often seen on a branch. It is not apparently much injured thereby, but their presence probably denotes an unhealthy state of the tree. Young plants are sometimes bored in the stem by grubs; this is remedied by cutting down the bored stem, and is not sufficiently general to do much damage.

Deer and cattle do little damage to young teak in the forest. Cattle boys do more damage in mischief than their cattle.

In para. V it has already been stated that teak is very much averse to direct cover, even of the lightest. It grows lanky and crooked, but recovers itself when disengaged. With our other hard woods, if started at the same time and kept free of rapid growing soft woods, it can take care of itself fairly well. In mixed forests it often becomes dominated by the soft woods, as also by some of its companion hard woods, such as *Pterocarpus marsupium* and *Terminalia tomentosa*, which grow to a greater height. Its growth is much retarded thereby, but it is long suffering, and having lasted out its tormentors, makes a fresh start.

It is generally found in mixed forest with Terminalias, *Pterocarpus marsupium*, blackwood, &c., but often a clump of teak trees is found in the forest. Sometimes in high forest an area of two or three acres is seen full of teak, with here and there a tree of another kind.

A few instances of this sort are to be seen in the Nalkery forest in Coorg. In some parts of Mysore there are coppice forests of almost pure teak. Here the superior coppicing property of the teak, its ability to withstand fires, and the respect with which it is treated by the natives as a reserved tree, have left it in sole possession.

XI.—RESULTS OF EXPERIENCE HITHERTO GAINED REGARDING ITS ARTIFICIAL CULTIVATION.—Attempts to raise teak in the forest by direct sowing have always been lamentable failures, and appear to lead to nothing but disappointment, loss of time and money.

PLANTING.—The best way to raise the plants is to make nurseries in February and put down the seed in the beginning of March, and water profusely.

The seed must be steeped in water for 48 hours before being put on the beds. It is necessary to put down a very large quantity, as only a small portion of it germinates. The beds should be carefully made with a diminutive wall all round them, three or four inches high, to keep in the moisture to a certain extent, otherwise the surface of the nursery would dry up again as soon as the watering was left off, the season of year being very hot and dry. The seeds, if well watered, germinate in three weeks, and by the breaking of the monsoon many plants are four inches high and ready to plant out.

The plants should then be put out in pits one foot deep at 6 or

6½ feet apart, which have been ready prepared. Planted at further distances than this the young plants take a long time to close up over the ground. 8×8 feet and 10×10 feet have both been tried in Coorg, the result being an enormous crop of weeds on the ground, which has to be continually fought against at great expense, in which the teak plants grow in a languishing way. At Nilambur 6½ feet × 6½ feet is said to be the best distance, so that in Coorg probably 6 feet × 6 feet would be the proper distance, as it is not such a forcing climate.

In planting out due care should be taken not to injure the roots, and the plants should in no case be handled by the naked hand more than is necessary. They should, when taken out of the nursery, be placed on a piece of bark and carried on it to the pit. The workman then thrusts his left hand into the middle of the pit, which has been previously filled with soil, and makes a wedge-shaped hole in the soil. He then takes a plant up with his right hand and transfers it to his left which he has kept upright in the pit, and keeping it in an erect position with the thumb of his left hand, he gently fills in the earth with his right and withdraws his left. He should then press the earth down gently round the plant.

The whole of the area to be treated should be planted in the first burst of the monsoon, and subsequently, after each break, it should be gone over again, and any vacancies should be filled up.

If this be done systematically, it should require no supplies thereafter, and it is always unsatisfactory to have to supply vacancies a second year.

Another great secret of success is to have a perfectly clean felling.

In most of the old plantations in Coorg jungle trees were left here and there, which are now a source of great annoyance, many of them have to be girdled to the heart wood before they will die.

Towards the end of the monsoon the weeds should be cut over, and the plants hoed round.

In subsequent years two weedings will be necessary, until the plants begin to close up at five or six years old.

After this it will not as a rule be necessary to do anything till the plantation is ten years old, when a thinning should be made; after which repeated thinnings are required at intervals of three or four years, the interval becoming longer as the plantation becomes older. Parsimony in weeding in the early years is a great mistake; the weeds should never be allowed to get over the plants. If this is attended to, the plantation may be said to be established the fourth year.

In favourable localities, where labour is to be got with facility, the cost would probably not exceed Rs. 50 per acre for the six years, but in Coorg, labour being expensive, the cost is higher.

Statement showing the Enumeration of Annual Rings of Teak in Nalkery Forest.

No.	Girth.	Height to first branch.	No. of rings per inch from the centre 1st inch.	2nd ditto ditto.	3rd ditto ditto.	4th ditto ditto.	5th ditto ditto.	6th ditto ditto.	7th ditto ditto.	8th ditto ditto.	9th ditto ditto.	10th ditto ditto.	11th ditto ditto.	12th ditto ditto.	13th ditto ditto.	14th ditto ditto.	15th ditto ditto.	16th ditto ditto.	17th ditto ditto.	18th ditto ditto.	19th ditto ditto.	20th ditto ditto.	21st ditto ditto.	22nd ditto ditto.	23rd ditto ditto.	Age.	Cubic contents of logs obtained.
1	...	...	11	16	10	19	19	26	17	17	24	14	...	...	...	...	...	...	...	...	...	...	...	...	173	
2	...	...	8	14	9	9	28	4	6	16	17	24	28	11	...	...	...	...	...	...	...	...	...	...	174	
3	9·7	32	12	5	18	5	4	4	11	25	11	28	8	13	13	15	14	17	22	20	25	30	45	...	345	
4	10·3	40	5	7	7	4	2	2	3	3	4	4	5	5	7	$9\frac{1}{3}$	8	10	12	13	7	17	22	15	9	180
5	7·0	36	3	4	5	5	5	3	3	7	9	12	15	28	44	23	...	...	...	...	...	...	...	...	...	166
6	8·4	30	7	28	9	3	5	10	8	7	5	8	13	19	...	...	...	...	...	...	...	...	...	...	...	122
7	7·9	25	7	22	23	12	16	10	10	5	7	9	14	18	22	16	...	...	...	...	...	...	...	...	...	191
8	7·2	39	9	7	6	6	4	5	7	7	10	12	8	$12\frac{1}{3}$	15	25	...	...	...	...	...	...	...	...	...	133
9	...	...	4	6	7	13	7	9	20	20	24	22	21	20	...	...	...	...	...	...	...	...	...	...	...	173
10	8·0	21	7	6	12	21	11	8	16	14	14	12	11	8	10	12	8	17	16	...	...	...	...	...	...	203
11	..	..	6	12	12	12	13	18	26	8	25	41	28	...	...	...	...	...	...	...	...	...	...	...	...	201
12	9·7	32	9	6	5	13	4	10	19	11	4	6	19	23	25	28	...	...	...	...	...	...	...	...	...	182
13	8·0	33	5	18	22	18	18	22	27	21	9	7	9	21	19	23	18	24	16	...	...	...	...	...	...	297
14	7·0	16	5	11	16	5	18	19	9	30	18	15	29	29	35	22	...	...	...	...	...	...	...	...	...	261
15	8·0	35	6	8	11	12	8	7	27	17	10	26	13	8	13	21	17	22	...	...	...	...	...	...	...	226
16	11·0	45	12	10	5	7	5	5	7	8	12	14	14	11	17	13	10	11	11	17	21	23	16	...	...	249

58 cubic feet
49 „
75 „
99 „

The Cape Forests.

Report of the Superintendent of Woods and Forests, M. le Compte Vasselot de Regne.

(*Continued from page* 153.)

III.

Condition of Well-known Countries from a Forester's point of view.

Remarks on management of the forests of various countries, with statistics of yield, exports and imports of timber in each country.

Having shown the part which forests play in the constitution of climates, we will now, in order to judge by comparison of the circumstances of the Colony in relation to its extent of timbered lands, cast a rapid glance over the extent of the forests in well-known countries.

Sweden.

Total area	.. ..	51,530,000 morgen.
Forests	.. ..	20,430,000 „

or more than 40 per cent. of the territory. The annual production is 1,050 millions of cubic feet.

The Crown forests have an area of 3,980,000 morgen.

Production is exceeded by consumption, exportation included; and the result is the gradual destruction of the forests. The Government, however, devotes annually a sum of £12,000 to the acquisition of forests in order to enlarge the State domain, and thus endeavours to secure conservation of a timbered area sufficient for the country.

Norway.

Total area	.. ..	36,784,000 morgen.

The wooded area comprises between 7 and 12 millions of morgen.

British Isles.

Total area..	.. ..	76,000,000 acres.
Forests ..	.. ..	1,500,000 „

Timber for constructive purposes is produced in the Crown forests and in private domains, and is found, to a large extent, in quickset hedges, parks, and isolated plantations.

Dr. Becker estimates that a property which does not possess trees, with trunks of various ages, equal in value to twice the rent of the estate, is not sufficiently stocked with timber.

Besides the timber which she receives from her Colonies, England imports annually from Sweden 5,600,000 cubic feet of sawn wood, and also considerable quantities from Germany, Austria, and Russia.

British India.

The total area exceeds 400,000,000 morgen.

Besides the timber absorbed by local establishments, the forests reserved by the Government occupy an area of rather more than 50 millions of morgen. These forests are managed by an administration recruited by means of young men selected by the Queen for studying the art of forestry at the French School at Nancy. These British subjects are not, however, provided with appointments until they have shown themselves capable of filling them satisfactorily.

Forest staff recruited by selected British subjects trained at Nancy.

Cyprus.

Total approximate area	..	1,200,000 morgen.
Woods and forests	..	200,000 „

Soon after taking possession of the island, the British Government applied for a French expert to organise the forest service there. This officer is now at work.

Dominion of Canada.

Total area	... ...	170,500,000 morgen.
Forests	... ...	93,200,000 „

The rapidity with which disafforesting has taken place in the country has already caused the gravest apprehensions in certain parts of this continent.

New Zealand.

Total area	... ...	31,700,000 morgen.
Forests	... ..	5,660,000 „

Mauritius.

In this island they are replanting with the conviction and zeal taught by experience acquired at great cost.

Mauritius, now being replanted.

Denmark.

Total area	... ...	4,400,000 morgen.
Timbered area	... ...	232,000 „

The area managed by the Government is of about 45,000 morgen. It comprises cultivatable lands conceded to forest agents, whose emoluments take the form of a percentage on the profits of the productions of the forests. It also includes lakes and roads.

Forest agents paid by a percentage on profits.

From 1871 to 1875 the excess of importations over exportations had risen to 11,200,000 cubic feet.

Since 1805 Denmark has bestowed serious attention on replanting, and since 1864 the Government has pressed forward this work with redoubled and patriotic energy.*

* Dr. Muller, Professor at the Academy of Agriculture and Forestry, Copenhagen.

RUSSIA.

Total area ...	...	562,795,000 morgen.
Timbered area ...	...	224,000,000 „

of which 147,600,000 morgen belong to the State.

The forests, although covering more than 40 per cent. of the total surface of the Empire, are very unequally distributed. They preponderate in the northern provinces, where they form an unbroken belt between the polar regions and the 59th degree of latitude, but are very scanty in the southern provinces, without the possibility of establishing the requisite equilibrium. Moreover, while exporting a great quantity of timber (valued in 1871 at £2,247,153), the Government has been none the less compelled, by sheer necessity, to carry out works of replanting in the southern provinces.

FRANCE.

Total area ...	...	61,395,000 morgen.
Timbered area ...	...	9,300,000 „

of which 3,488,000 morgen are *subject to forestry regulations*.

There are also eight millions of morgen in furze, heath, and common brushwood, which do not exercise anything like the same influence as trees do, and are considered as waste lands from which no revenue can be derived.

The timber imported in 1878, the last year for which I have particulars, represented a capital sum of 220,600,000 francs (say £8,824,000), exceeding by £7,500,000 the value of the exportations.

France is generally considered as insufficiently stocked with timber.

On the central plateau, in the Cevennes and on the Pyrennees *and Alps, large extents of forests exist.* However, the English writers, Forbes, Tyndall, and Whymper, give a melancholy description of our mountains. But the Government is pursuing energetically, and with complete success, the rewooding of the denuded parts. The works undertaken in execution of the law of 1860, extend over more than 80,000 morgen, and it is roughly estimated that they ought to embrace an area of more than 800,000 morgen, or ten times the area originally estimated for.

ALGERIA.

Superficial area ...	...	72,000,000 morgen.
Forests (about) ...	...	2,300,000 „

Say one-thirtieth.

Opinions are unanimous as to the insufficiency of the wooded surface of this country.

The Municipal Council of Tlemcen has unanimously adopted the conclusions of a report in which it is stated :—

"You have all remarked, Gentlemen, that years of drought follow the detimbering which is going on. Numerous springs

are dried up, and the yield of those which we so much admired, and which used to supply us with abundance of water, has diminished by one-half. With respect to France, it is generally acknowledged in theory, as well as a practical necessity, —as much in regard to climate as in view of keeping up a supply of wood for fuel and for constructive purposes—*that one-fifth* of the area of her territory should be reserved for the culture of forests. We may therefore admit, without laying ourselves open to the charge of exaggeration, that in Algeria, on account of its elevated temperature, hot winds, and the aridity of the neighbouring countries, the timbered portion should be increased to *one-fourth* of the total area."

COCHIN CHINA.

Total area	...	...	6,540,000 morgen.
Timbered	...	...	930,000 ,,

Say 13 per cent. of the total area.

MARTINIQUE AND GUADALOUPE.

The forests occupy from 20 to 25 per cent. of the total area.

BELGIUM.

Total area	...	...	3,530,000 morgen.
Timbered	...	...	564,000 ,,

The importations exceed *six millions of cubic feet.*

In 1854 the Government promulgated a Forest Code, containing severe penalties; and in 1864 established a School of Forestry at Bouillon.

GERMAN EMPIRE.

Total area	...	...	63,372,600 morgen.
Forests	...	...	16,454,780 ,,

or a little more than a fourth of the total area.

Forests are regarded in this Empire as an element essential to the national prosperity, and are, therefore, conserved and treated with scrupulous and attentive care.

A law of the Kingdom of Saxony enjoins the State to acquire all forests of which the public interest demands the conservation.

AUSTRIAN HUNGARY.

AUSTRIAN CIS-LITHUANIA.

"The north-western region, comprising Bohemia, Moravia, Silesia, and the plain which occupies the left bank of the Danube in Upper and Lower Austria—that is to say, the richest and most populous provinces of the kingdom—*is a country* whose forests occupy 29 per cent. of the total area." "Here," says Mr. Wesseley, "is a community of pre-eminent intelligence *in whose midst forestry societies flourish; where the forests,* instead of being stocked, as those of other parts of the Empire, with the species implanted by nature, are composed of the varieties which the hand of man has substituted for them. The

latter have been planted partly on account of their complying more satisfactorily with the demands of consumers, but chiefly on account of their superior value from an investor's point of view. It may, therefore, be said that in this region the forests are the work of man in a sense similar to that applicable to agricultural or industrial productions. Several railway companies use wood as fuel in their locomotives."*

Austrian Trans-Lithuania.

The forests of Austrian Trans-Lithuania have not been examined sufficiently for us to state their area. This region, however, is abundantly stocked with timber.

The excess of exportations over importations amounts to £2,835,100; nevertheless, Austrian Hungary, with all its wealth of timber, is none the less compelled to carry out works of replanting.

The "Karst" Desert, how caused.

The coast region, from the Duchy of Gorz and Istria, to the southern extremity of Dalmatia, including the slopes of the Alps abutting upon them, was formerly flourishing and fertile, inasmuch as it was protected by fine forests, whence the Romans, and subsequently the Venetians, obtained timber for ship-building. But abuse of pasturage, reckless felling, and grubbing up, have caused a large portion of these forests to disappear, and the region has been transformed into the stony and sterile desert called the *Karst*, with some few and thinly-wooded patches scattered over it like oases. Great efforts are being made, however, to replant this region.†

SPAIN.

Total area	.. ...	58,140,000 morgen.
Forests	... ...	5,930,000 ,,

of which a portion is brushwood.

The quantity of timber is notoriously very insufficient, and an Act, dated 11th July 1877, provides for replanting, which operation is entrusted, like the administration of the woods, to the Corps of Ingenieros de Montes, recruited from the Forestry College at the Escurial.

ITALY.

Total area	... ..	34,418,880 morgen.
Forests	... ...	4,712,000 ,,

In Italy also the necessity has been proved for extending the timbered area; and in 1877 a law was passed, designed to protect the forests, and to give an impulse to works of replanting.

GREECE.

Total area	... ..	6,046,000 morgen.
Forests	... ...	950,000 ,,

Say 15 per cent. of the total surface.

---

* Report made on the Vienna Exhibition by Professor Mathieu.

† Report by Professor Mathieu on the Vienna Exhibition, 1874.

ROUMANIA.

Total area	...	17,790,000 morgen.
State forests	...	950,000 „

I have no exact data of the extent of private forests.

These particulars have been collected by M. B. de la Grye, French Forestry Expert, charged by the Government of Roumania with making a reconnaisance of the forests of the country.

TURKEY IN EUROPE.

Total area	...	31,400,000 morgen.
Forests	...	1,657,000 „

TURKEY IN ASIA.

Total area	...	145,000,000 morgen.
Forests	...	3,284,000 „

These extents have been estimated by M. Bricogne, Forest Expert, whose services the French Government had much pleasure in placing temporarily at the disposal of the Ottoman Government.

UNITED STATES OF AMERICA.

I have not, at this moment, documents sufficiently precise to enable me to give figures. The data of those, however, which I have before me, show America to possess very rich forests; but she is considering what measures should be adopted in connection with the decrease of her timber. Several of the States have passed laws for securing the replanting of their territories.

From this cursory examination of various facts, it will be seen that even those countries, possessing the fewest forests, are much better wooded than the Cape Colony is, even if my estimate of its timbered area were too low by one-half or more. But the Colony possesses excellent kinds of indigenous timber.

Very small extent of forests in Cape Colony.

Indigenous timber.

The small quantity of forests which it includes would suffice, if properly conserved, improved, and enlarged, as regards the present, for the requirements of a population still few in number relatively to the extent of its territory.

Present forests of the Colony might under proper treatment supply its present wants.

Finally, the exceptionally good nature of the soil renders success certain if the work of planting the mountains and the sandy coasts is undertaken with determination.

Excellent nature of soil and prospects of success in replanting.

But the development of the Colony is, at this rate, like the idea expressed in these words:—"Forests precede a population and deserts follow it."

(End of Part II.)

PART III.

RECOMMENDATIONS.

Examination of Crown Forests.

The Colony possesses very few forest in comparison with the extent of its territory.

Survey of Crown forests.

No time should be lost in examining with the greatest care all those portions of the forests which belong to the Government, and, in conducting such an examination, to make a classification of their contents; and they should also be surveyed by making a plan of the untimbered area necessary for their maintenance, while steps should be taken as soon as possible in regard to most active measures for ensuring their conservation.

Conservation urgently necessary.

Question of ownership to be promptly decided.

The question of ownership should be decided without delay, at least in so far as concerns lots in litigation in order that the true owner, whoever he may be, shall be able to look after his own interests, in the case of a private property, as well as for the public interests in that of property vested in the Crown.

Purchase of forests.

By a practice analogous to that recognised as necessary in Sweden, in the Kingdom of Saxony, and also in France, if, in the recently annexed territories, such as the Transkei, for instance, or elsewhere, there are forests, endeavours should be made to acquire them; this being the only means of preventing their spoliation, and ultimately their complete ruin and destruction.

Reason for conservation of Crown forests.

The Crown forests ought to be conserved and improved with all the more care on account of their limited area. The chief cause of their destruction is fire.

Preservation from fire.

In order to preserve the forests from fire, it is necessary, first, to clear the borders of the forest by burning in winter the grass which covers the ground, as is now done by Captain Harison.

Clearing away débris.

In the second place, we must clear the forest by removing the *débris* of felled trees.*

Fire-paths, to arrest progress of flames.

The next step will be to cut, at intervals of about every 200 yards, paths which will serve the double purpose of arresting a fire, and of facilitating the removal of timber, while at the same time contributing to the proper surveillance and control of the forest.

Stock of seeds and plants.

Finally, there should always be a sufficient supply of seeds in store and of plants in nurseries, in order that as soon as the ground has cooled the burnt tracts may be replanted.

* Waggons and oxen should be placed from time to time at the disposal of Captain Harrison, to enable him to clear the districts where timber has been felled. The proceeds of the sales would more than cover the interest on the capital expended.

It will be necessary to decide whether the foregoing measures are legally applicable to Crown forests situated in the midst of farms, as well as to those in locations.

Crown forests on private farms.

It will have to be determined also if it is necessary to introduce an Act embodying preventive measures, setting forth responsibilities, enabling repressive measures to be enforced, and supplying the void which now exists in our colonial legislation with regard to forests.

Legislation on Forestry matters.

Our forests are far from producing, either in material or in money, such results as the active nature of the growth of trees and the consumption of the Colony would lead us to infer is the case.

Present general management.

Investigations must be made into the age at which the trees may be felled, and into the capability of each forest.

Special instructions should be drawn up on this subject in regard to each forest lot.

Special instructions for each forest lot.

Among the species which stock the forests two kinds alone are very much sought for, *viz.*, stinkwood in the conservation of the Knysna, and sneezewood in the Eastern Districts.

Demand for stinkwood and sneezewood.

The system of felling by license has a tendency to cause these two woods to disappear.

Objection to license system.

In order to increase the production in material and money, and to keep up the supply of the foregoing valuable species, the ordinary fellings should be rated or assized according to the limited areas on which the material for disposal and that reserved shall have been previously noted, clearly indicated, and invariably marked. The part of the forest destined for felling should be sold at so much per foot by public auction, in order that the felling may be made conformable to the clauses of the conditions of sale.

System of sale of stinkwood and sneezewood by public auction.

In cases where existing circumstances may not render a public sale immediately desirable, agreements for felling should be made upon conditions as near as may be to those of public sales, or licenses should be issued with due regard to the *defined contents* and under similar conditions, or the Government itself might undertake the felling.

Restrictions regarding sale and felling of sneezewood and stinkwood.

Thus, by following one or other of the foregoing modes of procedure, we should eventually arrive at the best system of selling by public auction.

As a temporary measure, at places where there will be large contracts in course of execution, endeavours should be made to arrange with the contractor reasonable conditions for the extraction, on his own account, of timber which, in the interests of the forests and of the public, should be removed.

Fulfilment of Contracts.

Decayed wood, removal of.

At the same time a certain number of the superfluous and decaying trees, scattered over various districts, should be noted, marked, and sold, or cleared away, either in independent lots or in groups.

Stinkwood and sneezewood, growth of to be cherished.

Forestry operations should be conducted in such a manner as to encourage as much as possible the replenishing diffusion and growth of stinkwood and sneezewood in their respective districts.

Stipulations in felling licenses.

It being a principle that those who cause damage should make it good, and as felling always causes some waste in the forests, contracts made with purchasers, contractors, and licensees should always stipulate the number of working days allowed, in order that the Conservator may utilise these days in the manner most advantageous to the interests of the public.

Transport of timber. Roads.

For the purpose of facilitating the removal of the timber, and consequently its sale, waggon-roads should be constructed in all the forests where practicable.

Portable tramways.

A movable section of the Decauville Portable Tramway* should be available for each forest, and, being laid along the fire-paths branching out from the waggon-roads, would thus form feeders to these main roads or base lines of communication where felling is going on.

Clearing for new roads; co-operation of departments.

Whenever a new road has to be made through a division or district containing forests, the departments of Public Works and of Woods and Forests should co-operate in order to ensure that, in clearing away the trees, the felling of timber should be strictly limited to as much only as is absolutely necessary for the execution of the work.

Sawing-mills with water power.

Sawing-mills should be constructed near water-courses, and could use the water as their motive power, as well as at points situated between districts where much timber would be sold in small quantities; and at stations, whence it could be forwarded to other parts of the country.

Nurseries for replenishing forests.

In order to ensure the replenishing of the stock of trees, a nursery should be established in the vicinity of every district where felling is

---

* The "Porteur Decauville" is a small portable railway, patented in France, England, Austria, Belgium, &c.

It took the First Gold Medal at the meeting at Galway; and the inventor received the Cross of the Legion of Honour at the Universal Exhibition of 1878.

The line is composed of a series of sections of single lengths from 15 to 16 feet long, weighing from 110 to 120lbs., each capable of being put in position instantaneously without addition of cross pieces (or sleepers) of any sort.

The width of the way (the gauge) is from 18 inches to 2 feet; it costs at the factory from 4*s.* to 6*s.* the yard run. Waggons (carriages) adapted to the transport of wood, for earth works, and transport of supplies of all sorts, &c., are manufactured at the same factory.

going on; and particular care should be bestowed each year upon collection of seeds of the best kinds.

As regards the plots of ground to be planted in, the work must be carried on, according to circumstances, either by sowing or by planting; and there should be special instructions issued applicable to each lot.

Immigrant allotments.

In the divisions of George and of the Knysna, in determining the land to be allotted to immigrants, the basins in which water-courses take their rise should be reserved, as well as the slopes between which they flow, and, along the sides of the hollows, a zone of a breadth sufficient for the proper protection of the slopes. Co-operation between the Immigration Department and that of Woods and Forests would ensure the carrying out of these arrangements. I have reason to believe that the cost of replanting per morgen would not be excessive.

Government reservations on above.

Replanting lands.

In the first place, the Government still possesses sufficient land in the districts where re-wooding is most necessary, so that, for a long time to come at least, there would be no necessity to employ in the purchase of suitable land any large portion of the funds set apart for that purpose; while in many places plantations by seeds, protected from fire and from cattle, would suffice for the formation of new forests.

Examination of forest lots and reports thereon, before sale of Crown lands; and reasons for so doing.

In every case it is urgently necessary to provide for examinations from a forester's point of view, the results of such examinations being embraced in special reports, and always henceforth to precede the public sale of Crown lands. This course furnishes the only precaution possible against the sale of land on which reforesting is desirable; and this should be done whether any forest exists on the land or not, so that no necessity should arise for sooner or later purchasing lands at a price far in excess of their actual value.

Classification of Crown land lots.

In order that this precautionary measure should not too much embarrass the sale of land, these examinations should be first made with regard to surveyed lands, and afterwards of those lots on which surveys are in progress, classifying the Crown lands under pieces which should be reserved for wooding, and those which should be sold.

Forest land described in detail.

Under the head of "Forest Land" should be classed the following:—

1*st*.—Ground devoid of vegetation, and situated on the summits or slopes of mountains, extending to a level to be ultimately fixed for each division. Care should also be taken to specify those parts of the soil where forests are considered necessary as giving shelter from wind, and becoming condensers of atmospheric moisture.

2nd.—All ground having steep slopes, and those subject to erosion by water; and particularly those covered with *débris* of rocks, and shifting earth liable to be carried away to the mouths of rivers.

3rd.—Belts of land on which trees would be useful to protect the soil against erosion by rivers and torrents.

4th.—Lots necessary to form in each natural basin a wooded surface sufficient to control the action of water along their sides.

5th.—Tracts which should be wooded in order to protect the dunes and the coasts against the encroachment of sand and the injurious consequences of wind.

6th.—Ground which may be specially adapted for the growth of stinkwood and sneezewood, in order to satisfy the future needs of the Colony as regards these two valuable kinds of timber.

7th.—Ground surrounding railway stations and platelayers' cottages, or traversed by the different lines of railway.*

8th.—Ground, which can be most easily wooded, in localities where there is not, within a radius of 35 miles, a sufficient number of lots reserved under the conditions already stated with regard to timbered forests, occupying at least a tenth part of the territory, whose needs with regard to timber require to be satisfied.

Replanting of Bushes.

The formation of pine forests from seeds should be tried in those localities where only firewood is at present produced. Special instructions should be laid down for each lot.

Experiments with various kinds of trees.

Trees used in manufactures, the olive, mulberry, oak, cork, &c., should be tried on lots which appear to suit them, and which could be subsequently let or alienated without injury to the forest.

Land on the flats for experimental purposes.

A piece of ground should be selected on the flats, for making experiments with trees whose introduction would be profitable, where we could watch their growth, study their characteristics, and observe, also, the effects of the treatments applied to the various kinds found in different parts of the Colony.

In Europe such plantations are held in very great value.

The German Empire alone possesses *seven* forest nurseries. According to Dr. Baron de Seckendorff, Director of Plantations in Austria, and founder of the Plantation at Vienna, the object and usefulness of these establishments are thus described :—

Forest nurseries—aims and objects.

"The object of these forest nurseries is to proceed with method and perseverance in experimental forestry, and to make observations with a

* In pursuance of Resolution No. 3 of 1880, of the Honourable the Legislative Council.

view to ascertain the practical and reasonable principles on which forest operations should be applied to the conditions of a country, as well as to discover and make known the influence which forests exercise on the physical economy of a country, upon its soil, and upon its climate.

"The means of creating, conserving, and profitably dealing with forests are to be studied; also their extension, and the different modes of their cultivation, in order to discover the enemies of the trees, such as insects and *fungi;* and what means should be adopted to exterminate them. The machinery, tools, and contrivances for transport, necessary for the working of timber forests, must also receive attention. Another object is to obtain suitable outlets, and to discover the best processes for the utilization of the productions of the forests. In one word, these institutions take the initiative in all researches, with the view of drawing from the forests, with the minimum of expense and labour, the maximum of profit, and thus to augment the public revenue."

Locality for creation of necessary forests.

From a climatic point of view forests are absolutely necessary on the mountains extending from Komsberg to Compasberg. It is there that a great many of the rivers of the Colony take their rise; and, moreover, if the north-west winds reached the Karoo after passing over forests, they would very probably pour down on the dry plains a larger quantity of rain.

Planting of sandy dunes.

Planting the mountains of the Kareeberg would exercise a salutary influence on every portion of the divisions of Fraserburg and Victoria West, comprised between this chain and the Nieuwveld, as far as Prambarg. The westerly winds would be cooled, and would bring more rain, if the sands on the Western Coast were planted.*

Planting along banks of the Orange River.

Finally, plantations on the heights, destitute of timber, which command the banks of the Orange river along a portion of its course, would cool and moisten the north winds to the advantage of the whole country.

Effects of planting the mountain sides and sandy dunes.

The planting of the mountains and of their slopes, combined with similar operations on the edges of streams, would bind the soil together; while plantations on the dunes would fix the sands, and then, at no remote date, perhaps, the mouths of certain rivers, now closed, would become practicable for navigation.

Mountainous locality recommended for planting.

I do not hesitate to recommend this work to the most earnest consideration of the Government. I am of opinion that it should be commenced on the mountains situated to the south of Beau-

* I have described, in a pamphlet on the Sandy Dunes of the Coubre, the entire process of fixing sands.

fort; and, I believe, having already made an examination of these districts, and from particulars gathered on the spot, that there is every prospect of success in carrying it out. I am supported in this opinion by Captain Harison, with whom I have conferred at length on the subject.

Funds to be provided by alienation of Crown land lots.

With regard to the ways and means of creating the funds necessary to be provided for the expenditure which an undertaking of this nature would necessitate, I think they could be partly furnished by the alienation of lots, small in extent (say 10 morgen), of Crown lands, which, for this purpose, might be sold in detail. Large tracts of these lands exist in the portion of the division of Humansdorp, known as the Tzitzikama.

Advantage of above alienation.

An alienation under these conditions would satisfy the needs of many people; would encourage the formation of small holdings entirely cultivated, in lieu of large undefined extents of pasture lands periodically burnt; would attract to the country a numerous population, and would produce a considerable revenue for the Treasury.

Utilisation of timber.

If, as I have been told, the woods of the Colony have been properly tested, the results of these tests should be searched for. If necessary, fresh experiments should be made, in order to confirm and verify the former.

When the value or worth of these woods shall have been officially and indisputably determined, they should be employed in colonial public works for which they possess the requisite qualities. Care must be exercised, however, that the trees are never felled out of the proper season. We should follow the system of *conservation* which prevails in Europe.

Test sales for popularising use of the Colonial woods generally.

In order to render popular in the Colony the use of certain kinds of timber hitherto but little used, though of acknowledged good quality, it might perhaps be better to dispose of on account of the Government, and in marketable sizes, a certain quantity of properly selected timber, which should be sent to the principal markets of the Colony for the purpose of being publicly sold.

Manufacture of charcoal.

There is scope for inquiry as to whether the branches of the trees cannot be profitably converted into charcoal.

Staff.

In order to conserve and improve the forests of the Colony, and to increase their production for useful purposes, as well as to create the timbered surface necessary, officers should be appointed for this work, and there should be an organisation to render individual effort efficacious by means of co-operation. I think that such a staff should be gradually organised.

Forest conservation of the Knysna.

The divisions of George, the Knysna, and Humansdorp, constitute the Conservation District of the Knysna.

Operations of Capt. Harrison.

The Conservator, Captain Harrison, has indeed done all that he has been able to accomplish, under the circumstances in which he has been placed, *towards protecting the forests entrusted to him.* He has carefully followed the instructions contained in the Regulations so as to insure felling the trees at the proper season. His efforts have been attended with no great results, because the system of licenses does not allow of them; but he has, nevertheless, made efforts to localise the felling of timber to places where supervision was possible, and also for the removal of mature trees from the open sections. He has prevented the total disappearance of stinkwood from certain lots by forbidding the waste of this precious and rare kind for purposes for which wood of less valuable species are suitable.

He has rendered real service by insisting on the use of colonial woods for sleepers and telegraph poles.

He has busied himself in keeping woodcutters employed around the forests.

He has shown true discernment in the recruiting of his staff, being aware that the functions of ranger cannot be properly discharged except by respectable men drawn from the labouring classes, who will not endeavour to escape from the hard daily work which their occupation necessitates, and having the degree of intelligence and the information necessary for the due discharge of their duties.

He possesses a thorough aquaintance with the woods, climate, and soils of the districts. He has experience in the service, and instead of confining himself to running in the usual groove, he has not ceased to search for improvements and to recommend them.

Whenever his assistance may be required in making the dispositions necessary for the management, improvement, completion, and extension of the forest scheme of this district, I have no doubt that his experience will be very useful, because experience is combined in his case with a mind amenable to all progress.

Additional ranger for Knysna forests. Mr. Dunn's contract.

At present it appears necessary to appoint an additional ranger in the Forest Conservation of the Knysna, in order to supervise the felling in the locality where Mr. Dunn is preparing the 500,000 sleepers comprised in his contract.

Eastern provinces.

The omissions and absence of co-operation in the forest service of the Eastern Provinces have been referred to in before.

Before undertaking in this district what is necessary for the conservation of these rapidly-decreasing forests, it is absolutely essential that a superior forest officer should be appointed for the purposes of centralising the correspondence, administering the primary preservative measures against fire, as well as against the unseasonable destruction of young saplings and felling of timber; and to initiate investigations as to the durability and the felling of the timber, together with the capability of the forests.

Superior forest officer, Appointment of.

This officer should possess the following qualifications:—

Qualifications of above officer.

A knowledge of timber;

A knowledge of the country;

A knowledge of the laws of the Colony and of the regulations of its Civil Service.

He should be of such age, education, and social position, as would permit him to associate, on equal terms, with Civil Commissioners.

He should possess sufficient activity to enable him to make the extended investigations in the forests which his duty demands.

As has been remarked before, a ranger at Kieskama Hoek, as an Assistant to the Conservator, would be of great service.

A third functionary is indispensable to the Colony, for the works of replanting on the flats, for those to be undertaken at Beaufort, for the plantations to be continued there, and for general forestry service in the Western districts.

Officer for replanting and general forestry work.

In my opinion, for the purposes of determining the yield, and making an inventory of the material of the forests, and for stimulating the activity of the other branches of the service, it will be necessary to procure the assistance of an experienced forester, from the class of head-ranger (to be styled "Sub-officer, or Brigadier, of Forests"), having a thoroughly practical acquaintance with all the details of forest work, and able without delay to set the staff of colonial rangers at the work which forestry operations and fellings of timber for sale render necessary, including surveying and levelling.

Employment of a brigadier.

An assistant of this class was given in 1866 to every French agent charged with the survey of the forests of Turkey; and in this country, where it is necessary to establish a regular and permanent system for all the details of the Forestry Department, such a course is even more essential than it is elsewhere. No time, therefore, should be lost in satisfying this want.

This organisation, when completed, will suffice for initiatory measures; but as soon as the mode of felling by agreement shall come into vogue,

Organization of the forestry staff.

and the execution of forestry works, in addition to those proper to the conservation, improvement, and development of the forests, shall be decided upon and commenced, each superior officer will evidently need capable assistants, similar to those who are trained to assist heads of service in India, and who will in course of time take their places.

It has long been acknowledged everywhere that in order to take care of the forests we require officers who will study the trees from an economical point of view, as scientists and botanists do; who understand the cause and principles of growth and decay; who can prove, by demonstration, the experiments they make, and at the same time justify an axiom by experience; and who will be competent to direct works in connection with felling and replanting.

Training of forest officers.

The British Government, as the result of experience, has come to the conclusion that the best training is given in the School of Forestry at Nancy, and has entered into an arrangement with the French Government, by virtue of which each year a certain number of young men are selected to pass through the curriculum of that school. During their stay at Nancy they are under the charge of Colonel Pearson, formerly Conservator of the Forests of India.

Colonial young men recommended to be trained in France for forestry work, &c.

I would submit that the Cape Government should, without delay, select four young men in the same manner as is done by the British Government; and since they would be, as colonists, British subjects, it would suffice, I imagine according to the terms of the existing arrangement, to negotiate with the British Government to this end, in order that no obstacles or delays may intervene. I consider this step as the best possible that can be taken in the future interests of the Colony. The session of the course at Nancy usually opens early in November, and the duration of the period of study is from two to three years. There is, therefore, not a moment to lose if advantage is to be taken of the ensuing scholastic year.

Special services rendered by Forest Department of France, &c.

In France, forest officers are exempt from military service, strictly so-called, but they constitute an auxiliary army corps, which rendered eminent services during the invasion.*

I think that a similar organisation could be made as regards the Forest Service of the Cape Colony.

(*End of Part III and of Report.*)

* See the commendatory remarks of the Duc D'Aumale, with reference to the Bazaine Trial, and the letter from General Gambriels.

CONCLUSIONS.

Summing up of operations recommended.

The general view of the course thus marked out comes under three heads. :—

1*st.*—The application of the best possible treatment to the existing forest lands.

2*nd.*—The introduction of timber trees among the bushes.

3*rd.*—*Planting trees on lands where forests are necessary.*

Ends to be attained.

These three measures, pursued with energy, confidence, and perseverance, will lead to the following results :—

1*st.*—To draw from the Colony itself all the wood necessary for its own consumption. By this means an annual sum of £500,000 or more will be expended here instead of as at present, paid to foreigners; this is borne out by the Custom House Returns of Importations, and will, without doubt, lead to a greater increase of wealth in the future, in preparation for becoming a wood-exporting country at a time when wood will be more scarce in other parts of the world.

2*nd.*—To regulate the water-courses, and render drought, from which under present conditions the Colony suffers less frequent.

3*rd.*—As a consequence of these two effects the development of colonization will be powerfully helped forward.

THE DRY RAKHS OF THE PUNJAB.

By Daulat Ram Bimbhat.

The word Rakh is a Panjabi word, derived from Sanskrit *Raksh*, which means some thing reserved or protected.

Formerly all the villagers, who lived inside, or in the vicinity of the rakhs, were permitted to pasture their cattle free in the rakhs; but since the Forest Department has come into existence, grazing dues are levied.

I would confine my remarks simply to those rakhs, which go by the name of Bár, and lie between the rivers Ravi and Chinab, between parellels 31° and 32½° of North Latitude, and 71° and 73° of East Longitude.

This tract of land lies in the arid zone, where the rainfall does not exceed 15 inches. The fall diminishes as we go south-west. For instance, a little beyond Mooltan, it is only 7 inches.

We are here in the alluvial plains of the Punjab. Crossing the Ravi from Lahore, we find the soil at first free and quite moist from sub-soil percolation; wells can be easily sunk, and at little cost. As we go further, the land rises slightly, the soil looks fertile, but is destitute of sub-soil moisture, and agriculture is carried on by means of very deep wells, from which the water is lifted with Persian wheels. A single well is sunk by several cultivators clubbed together, and each one uses it in turn. The scarcity of water is so great that the wheels are worked day and night. As we advance further into the interior of the Doab, the depth of the water-bearing stratum increases, and the country has almost the appearance of a desert.

The soil consists of a very hard clay, which is often saline, and rings with a strange hollow sound under the tread of horse or man. As all the vegetation on the ground consists of a few shrubs and scattered tufts of grass, with small trees here and there at long intervals, the soil is caked and hardened by the direct heat of the sun, helped by the continual treading of

camels, buffaloes, cows, &c., which roam over it in thousands during the rainy season. The clay is so stiff and plastic that the footprints of goats, sheep and cattle remain faithfully impressed in it; and, when rain falls, the greater portion of it runs off superficially, very little being able to get into the soil.

The climate of the tract I am describing is milder than that of many other places in the Punjab. The people are strong and healthy.

The chief, as well as the largest tree, is the *Prosopis spicigera* (jand), mixed with *Zizyphus* (bér), *Salvadora oleoides* (van), and *Capparis aphylla* (karir), and, in some places, where the rainfall exceeds 15 inches, with *Acacia leucophlœa* (reru). There are a few other species besides, which are however of little or no value. Even the *Prosopis spicigera* is, at the best, only a moderate sized tree.

In spite of the hard and stiff soil and subsoil, which keeps back or excludes other species, the jand is able to remain easily the dominant tree (although a stunted one), thanks to its long and strong taproot, which has been known to penetrate 60 feet into the ground. The jand thrives best where the rainfall is between 15 and 30 inches, and disappears altogether where this latter exceeds 40 inches.

Its small, flat seed is caught in the numerous crevices and holes to be found in the clay soil I have already described, and is not easily washed away like the large round seeds of *Zizyphus*, *Salvadora*, and *Capparis aphylla*.

The seed is shed in the months of June and July, just before the rainy season, and is not injured by the strong heat of the sun. When rain falls, it germinates readily, and at once develops a strong taproot capable of forcing its way into the ground.

Jand is long-lived and long-suffering. Although it is treated very badly both by men and animals, who cut it down year after year, tear off its bark, and nibble off its terminal shoots, it still holds its ground. Rai Melá Ram, the great fuel contractor of Lahore, stubbed out the roots of this tree from his private rakhs, but an abundant crop of root-suckers took the place of the trees that had disappeared.

Jand is proof to the severest heat and frost. In the Kot Lakhpat plantation near Lahore, where the climate is excessive, babul is killed down to the ground by frost year after year, but the jand flourishes without the slightest trace of injury.

Thanks to its small leaves, narrow crown, and long tap root, the jand has nothing to fear from violent winds, which uproot or mutilate many of its companions, especially reru (*Acacia leucophlœa*.)

The seed of the jand possesses great vitality. I once sowed some seeds which had been gathered two years previously, and kept without any care. They had been heaped up on a kutcha

floor, exposed to dry and moist winds. They germinated very well.

In connection with the faculty which the jand possesses of throwing up root-suckers, I may say that I have been told that it may be propagated, like sissoo, by means of root cuttings. My experiments to test this peculiarity failed, but I am afraid I worked out of season.

All the peculiarities I have just given combine to render jand a gregarious tree. Nevertheless one may ask why, if jand is so hardy, and able to flourish under the most adverse conditions, the rakhs are so badly clothed with trees. I would reply as follows:—

I. These areas have not yet been reserved. The rights of surrounding villagers are not defined or settled, and no thought is given to the regeneration of the forest.

II. Grazing is unrestricted. Seedlings are greedily devoured by goats and buffaloes. The young foliage, terminal shoots and flower-bearing branches of young trees are torn or eaten up directly by camels, while those of larger trees are bent down, broken, wrenched or lopped off by the herdsmen armed with long pruning hooks. Often the bark is torn off right down to the base of the stem.

III. The ripe seed (*Sangar*) is gathered, and is a favourite article of food with men and cattle. People gather the seed by thousands of maunds, and sell them in neighbouring towns and villages. The seed collectors have no more mercy for the trees than the herdsmen.

IV. People go into the rakhs and cut how and what they like.

If the causes of destruction that I have just briefly stated are removed, there is every hope that we shall, in time, not only see the rakhs densely stocked, but the trees attain the maximum size of their race, and not remain as they are at present, mere stunted bushes.

When it is left undisturbed, jand has been known to attain a height of 60 feet with a girth of 9 feet.

Besides this, when in November last I visited the rakhs I am describing, on official duty, I came across many ruins of cities, villages, tanks, wells, and temples, and noticed, moreover, the dry beds of ancient streams and pools, which at once convinced me that this part of the country must, at one time, have been in a flourishing condition, and that it had since undergone a very sad change indeed.

Near the village of Mahandai, the head-quarters of the forest ranger, I found a very large dilapidated fort, and not far off the ruins of an extensive city, which, the villagers told me, had once been so powerful that it had repelled thousands of invaders from the frontier. The dry streams, which now flow only in the rains, must once have been perennial. But

now the whole region is a vast desert, studded with a few hovels of wandering lawless men, who graze herds of cattle stolen from the neighbouring agricultural districts. Among them no man may wear a turban, unless he has stolen something. During the hot weather men and cattle drink from the same pits, the water in which may be aptly termed liquid manure.

The importance of these rakhs, as fuels and grass preserves, is very considerable. They supply all the neighbouring centres of population, including Lahore and other large cities, with firewood and grass. They sustain a noble breed of cattle, sheep, and goats. In them are pastured thousands of camels, which mainly carry the Kabul trade.

I will now say what I know about the propagation of the jand. The seed ripens in June and July, and can easily be kept, provided it is protected against the ravages of mice, rats and insects.

I myself sow from April to May, and even up to the middle of June. In my opinion it is best to sow on ridges.

Another method followed is to sow on the sides of furrows or trenches, which also serve as irrigation channels. The Kot Lakhpat plantation was sown in this manner. The trenches are dug 10 feet apart and one foot wide. The soil on the western side is loosened, and the seed is sown in a single line, just above the height reached by the irrigation water. Germination takes place in from ten to fifteen days. Water must be given every alternate day until the seed germinates. In no case should water flow over the seeds or the base of the seedlings, as (I say this from my own experience) death will ensue in most cases. Water ought to reach the seeds as well as the young plants by capillarity. In the Kot Lakhpat plantation, 25 acres of blanks were successfully stocked by sowing on small mounds round which the irrigation channels passed. The earth below the mounds had been previously loosened, and the mounds themselves were made up with the lowest layer of earth loosened. The mounds were 10 feet from each other in lines 20 feet apart.

Jand may be cultivated in the poorest soils, even in what is called *Kallar* in the Punjab, but there must be a sufficient supply of moisture at the beginning.

THE KORAI TEAK FOREST.

By Chandra Kumar Chatterjee.

The Korai block is situated partly on the edge and slope of the Korai Ghat, and partly below the Ghat. Its area is about 31,000 acres.

Below the Ghat the soil is alluvial ; on higher ground it is disintegrated gneiss. Trap occurs near the edge of the Ghats, and is often capped with laterite.

Area for area, this block is more valuable than any other of the Satpura forests. It contains a very large propor-

tion of teak, which, for the most part, is straight and well grown, averaging 18 inches in girth. Teak is quite the dominant species throughout the area, and is mixed with bamboo, tinsa, dhaura, lendya, salai, achar, aonla, kusam, khair, dhaman, dhobain, padal, bijasal, saj, shisham, gulu, &c.

The forest has been protected from fire since 1872. Protection is effected by clearing and burning completely an outer line, about 400 feet wide. For the purpose of easily localising fire, in case one occurred, the whole area is divided into seven sections by burning an internal line 200 feet wide.

(1). Along the road from Rukhar to Sakadai, across the feeders of the Jamun and Bawanthari nullahs.

(2). From Rukhar to Jamun nullah.

(3). Along the Dongria nullah for about two miles, and then along the flat crest of a hill up to Sangaur nullah.

(4). Along the road leading from Chunderpur to Dorasee Khassa.

The result of fire protection in this forest is very marked, especially in the three compartments adjoining the Nagpur road. Young coppice growth, which, prior to the introduction of this measure, was either burnt down annually to the roots, or greatly scarred and thereby damaged, is now progressing in a satisfactory manner both above and below the Ghat.

The poles are straight, clean, and covered with healthy bark and foliage, and quite different in appearance to similar stock in the unprotected forest west of the road.

The soil, too, year after year, assimilates more vegetable matter, receiving back the chemical constituents drawn from it by the trees and grasses; and what is a matter for congratulation, a plentiful crop of seedlings, for the absence of which the forest was formerly conspicuous, is now springing up in all places, where the essential conditions of light, soil, and seed-bearing standards exist.

At Korai especially, where the above conditions are perhaps better than elsewhere, seedlings of teak saj, khair, and rohan are rapidly filling up the small blanks adjoining seed-bearing trees, and where these latter are present in fair numbers, it is certain that we may rely on the forest being regenerated by natural means. The growth of these self-sown seedlings, however, remains very slow, and they appear to require many years of uninterrupted protection before they attain even the height of our forest grasses. They may, however, be assisted by being relieved of the pressure of the surrounding and superincumbent grass at the beginning of the rains, obtaining thus a a free circulation of air, light, and room, for the spread of their small roots.

Experiments in the copsing of teak were undertaken in the Korai forest in the year 1877. The area chosen for the operation is situated between Rukhar and Sorkadongri. It contained

a very large amount of coppice teak, a large portion of which had been damaged by former fires, and from which it was hopeless to expect a future supply of timber. All such damaged trees were cut back over an area of 1,500 acres. 10,006 trees were so felled, yielding only 5,123 saleable poles. No better proof of the necessity of the work could be found than in the figures above noted; the stock was so wretchedly bad, that for every two trees felled we could obtain only a single marketable pole! The cost of the above work, including the collection and carting of the 5,123 poles to the Rukhar Depôt, came to Rs. 581-3-2, *i.e.*, Rs. 11-2-3 per 100 pieces; 3,682 pieces were sold from the Rukhar Depôt during the year 1879 as follows:—

Small poles 3451 = Rs. 690-7-9
Large poles 2,31 = Rs. 83-14-3

3,682 = Rs. 774-6-0

thus realising an average rate of Rs. 23-11-7 per 100 poles, or scarcely more than 8 annas per acre. *6,363 trees left standing* were at the same time freed from climbers.

The result of the experiment is a complete success. The trees were felled flush with the ground, and all the stools have thrown up vigorous shoots developed from dormant buds. Their average height in 1880, when they were three years old, was 16 feet.

A few strange cases were observed of stools remaining for a long time green, without developing shoots until towards quite the close of the rains.

A few then threw up shoots, others dried up, while the rest remained green up to my last inspection in 1880, but without having shown any sign of reproduction. I can offer no explanation of this strange freak.

Stools, containing from 20 to 40 concentric rings of growth, were the first to produce shoots, and these were generally more numerous and stronger than those developed on stools from 40 to 80 years old. On stools above this latter age, the shoots were very slow in appearing, and were few and weak in their after growth. But unless the trees or stumps were 100 years old and upwards, they appeared capable of being copsed successfully.

DEODAR IN KULU.

By Mian Moti Singh.

Forests in which deodar is the prevailing tree are generally found on moist loamy soils. The deodar affects northerly and westerly aspects most, although it is not seldom met with on other aspects. Indeed, the aspect it selects varies, as a rule, with the altitude at which it grows. For instance, between 4,000 and 6,000 feet above the sea the tree grows gregariously on northerly and westerly slopes, and less commonly on

easterly slopes, while *Pinus excelsa* very often forms pure forests on southerly aspects. Above 6,000 feet, on the other hand, it is on easterly and southerly aspects that deodar flourishes, growing there frequently almost pure, northerly and westerly slopes being occupied by the Himalayan spruce and silver firs.

The needles of conifers in the Himalayas form, when not burnt by fire, or triturated under the feet of cattle, a thick loose covering of undecayed vegetable matter over the soil. Deodar seeds that fall on such a covering, although they germinate freely enough, generally fail to extend their tap root, through it into the soil below, the result being that they are either washed away with the dead leaves by the spring rains, or are killed by drought. On the other hand, young seedlings of *Pinus excelsa* develop a tap root capable of piercing this loose mass of undecomposed leaves, and forcing its way into the soil, where they thus fix themselves firmly.

The Himalayan spruce generally produces from two to three crops of seed during the interval between one seed year of deodar and another. And hence, when these two species grow together, this circumstance alone, irrespective of some others, gives the former species a decided advantage over the other.

The advantages of having oaks growing with deodar are many. I may mention some of the principal:—First, the deodar by itself, or associated with other conifers, cannot form a complete leaf canopy. When oaks enter the crop, these broad-leaved trees fill up all the intervals between the crowns of the cedars, without, however, diminishing the number of the latter. They thus force and hasten the natural pruning of the cedar boles and they increase the production of the soil. Secondly, none of our oaks attain anything like the height of deodar, so that the former constitute a true undercrop, making growth on their own account, and pushing up the latter. Thirdly, and lastly, the mixed crop so obviously forms a much more complete cover over the ground, the soil being thus continually protected and improved.

The people in the Himalayas prefer the leaves of oaks as fodder to those of any other trees, and even to the various grasses themselves. Oaks are also cut for fuel before any other species. Oaks are, therefore, very heavily lopped, and are hence kept down or destroyed, so that where they might grow usefully with the deodar, pines and small broad-leaved trees remain the only effective, but comparatively inefficient, allies of that valuable tree.

It is a well known fact that young deodar is greedily eaten by sheep and goats; and that, although the stem of young seedlings is remarkably elastic, the heavy buffalo tramples down and crushes thousands of them under his broad cloven foot. I would, therefore, exclude grazing from every area that

is completely under our control. But when the undecayed layer of dead needles is so thick as to impede reproduction, I would admit cows in order to triturate the whole mass, facilitate its decomposition, and render it more compact.

Fires are not an annual occurrence in deodar forests, owing to the great altitude at which they often occur, and which preserves the moisture of the soil all the year round. But as the needles of conifers decompose very slowly, and are very resinous, they form a thick layer of highly combustible material, which, when once ignited, burns fiercely. Hence forest fires, when they do occur, are difficult to put out and do great damage. The only way to check or keep out fire is to trace fire lines, which should be kept clear of all combustible matter, and especially of cones. Unfortunately we have no deodar forests in the Punjab, which are thus protected.

SAL IN THE SAHARANPUR FORESTS.

By Kripa Nath Dey.

The Saharanpur sal tract extends from the Ganges near Hardwar to the Jamna, eight miles below Kalsi. The northern boundary is defined by the distinct watershed line of the Siwaliks; the southern boundary is marked by a well cleared line 15 feet wide.

This tract lies partly on the southern flank of the Siwaliks, partly on the flat ground below. The hilly portion of the area is cut up by deep ravines and gorges, with scarped and precipitous sides. The highest peaks attain an altitude of about 2,200 feet above the sea. The gradients of the slopes vary from 15° to 50°. From the ravines and gorges issue broad shallow water-courses called *raos*, most of which dry up in the hot weather, and the beds of which are flat expanses of boulders, water-rolled stones, shingle and sand.

Below the Siwaliks the soil is principally alluvial. The Siwaliks themselves consist of thick bands of shale, irregularly interbedded with conglomerates and boulder deposits.

The monsoon commences here about the middle of June, and lasts up to the end of September. In winter frosts are rather frequent and severe. Hot winds blow from the south during the summer months, bringing with them perpetual dust storms. The general aspect is southerly, but the sides of the spurs face respectively east and west.

Sal is the most extensively distributed of all species in these forests, and easily predominates or grows almost pure on the best soils, as in the Lakarkot and Ganjarban blocks, where it is associated with bahera (*Terminalia belerica*), Dhaura (*Lagerstræmia parviflora*), bhilawa (*Semecarpus anacardium*), jaman (*Eugenia Jambolana*), amaltas (*Cassia Fistula*), dhak (*Butea frondosa*), haldu (*Adina cordifolia*), aoula (*Phyllanthus Emblica*), and maljan (*Bauhinia Vahlii*).

Elsewhere, especially in the hilly blocks of Malowala, Dholkhand, Andheri and Bethban the sal occurs only in patches along the banks of large streams or on open level ground. There it is associated with sain (*Terminalia tomentosa*), sandan (*Ougeinia dalbergioides*), bákli (*Anogeissus latifolia*), bamboo (*Dendrocalamus strictus*), and chir (*Pinus longifolia*).

The new foliage of sal generally comes out in March, a few days after the old leaves have fallen. The trees also flower at this time. The seed ripens in June, and germinates immediately, often before falling from the tree, and an abundant crop of seedling springs up nearly annually, and covers the ground as with a carpet. The germination of sal is hypogeal.

The sal yearling develops a tap root upwards of two feet long, and is thus able to resist frost, and especially drought, well. Although both these causes may kill down the aerial portion of the seedlings, stronger and stronger shoots spring up year after year from the collum of the root, and ultimately shoot away upwards without any further risk.

The dimensions attained by sal in the Saharanpur forests vary according to the soil and aspect. On plateaux we find sound sal of 3 feet 6 inch girth and 18 or 20 feet to the first branch. Owing to generally unfavourable conditions, the sal in this tract becomes hollow at the centre at a very early age. It is common to meet with apparently sound trees that are quite hollow. The hollowness increases year by year, until the outside core becomes so thin that the trees are broken by the wind or snapped in two under their own weight.

Elephants commit a good deal of damage in various parts of the forest, especially in the Lakarkot and Ganjarban blocks, and also in the hilly portions. Their ravages have been chiefly confined to bamboos, which constitute their favourite food. Occasionally, we see the young sal trees knocked over by them.

The depredations of insects are very heavy. The grub of a certain species attacks sal leaves in the rains, and spares only the bare fibre. Last December nearly the entire foliage of coppice shoots was destroyed in this manner. White ants are very numerous and destructive.

At present there are in the Saharanpur forests, scarcely any sal trees fit for felling. The forest has been overworked, and now requires long rest and protection. The main sources of revenue are sales of minor produce and of dead and fallen wood of various species.

E. E. FERNANDEZ.

Cattle-grazing in Deodar Forests.

TO THE EDITOR OF THE "INDIAN FORESTER."

SIR,—I beg to invite the attention of the readers of the "INDIAN FORESTER" to the question of grazing of cattle in deodar forests, and will feel obliged for the expression of opinion on this important subject.

As for myself, I have had various opportunities from time to time, extending over a period of about ten years, of observing the effect of excluding cattle from deodar forests, and must confess that the result, as far as natural reproduction goes, has not been at all satisfactory.

When the conservancy of deodar forests was first taken in hand, the conclusion seems to have been naturally formed that it was absolutely necessary to exclude all kinds of cattle from such forests to ensure reproduction, often at a considerable amount of inconvenience and hardship to the neighbouring villagers.

My remarks refer principally to the forests of Chumba, Jaunsar, Bawar, Tair, Garhwal, Bussahir, and other hill states I have visited, and in most cases a comparison between forests left open, and those closed to grazing, by no means tends to show that much advantage has been gained by enforcing the closing process.

As a rule, as far as I have observed, the result of excluding cattle after fellings have been made is that a dense growth of grass and bushes of all kinds has sprung up, which, if it has not altogether prevented reproduction, has, at all events, hindered a large number of seeds from reaching the ground; and has also, probably, choked many young seedlings before they had time to overtop the grass.

On the other hand in the neighbourhood of closed forests one frequently observes patches of old deodar forest which are heavily grazed over, and in which a vigorous crop of young seedlings generally exists.

It may probably be argued by some of your readers that the real reason for the unsatisfactory state of affairs in the closed forests is that fellings have been made too severely or not executed on a proper principle; but this explanation can hardly, I think, be accepted in all cases, for I have often observed portions of open forests in which nearly all the trees have been felled by the neighbouring villagers, except the branchy ones left here and there; and in such areas, notwithstanding occasional fires and constant grazing, a magnificent crop of seedlings of all ages is often observable.

The probable cause of this satisfactory state of reproduction in the open forests is, that the grass and undergrowth has been constantly kept down, a certain amount of lateral shelter afforded by the trees left standing, and the feet of the cattle have tended to break up the turfs and thus enabled the seed to enter the ground.

On the other hand many seedlings are doubtlessly trodden down by the cattle, but on the whole I think the advantage seems to be on the side of satisfactory reproduction. It should also be observed that in such forests, the grass having been constantly kept under the damage done by an occasional fire, is very slight; whereas in the case of a conflagration breaking out in a forest which has been closed for 10 or 12 years, I think your readers will agree with me that "the latter state of that forest will be worse than the first."

It should be distinctly understood that I refer to the grazing of cattle only, for, although goats and sheep do not do so much harm in deodar forests, as they are supposed to do, especially when there is abundance of shrubs for browsing, still they undoubtedly nibble the top shoots of the deodar plants, especially when snow is on the ground.

It should also be understood that in places where sowings or plantings have been made, the entrance of cattle for a number of years, at all events, is of course out of the question.

As an example of what I have endeavoured to explain above, I may mention the case of the Koti deodar forest, situated in the Jaunsar Division, School Circle, N. W. P. Considerable fellings, nearly equally distributed all over the forest, were made during 1870, and since that time the forest has been successfully protected from fire and grazing of all kinds. The result, however, is not at all satisfactory, the whole area being now covered with a dense growth of grass and bushes, (principally *Indigofera heterantha* and *Desmodium tiliæfolum*), and few deodar seedlings are to be formed except those that existed at the time the forest was closed. An interesting and striking contrast can also be made between the state of the closed forest and that of a neighbouring open patch called Sunrere, situated a short distance from the Koti forest. In the latter, heavy fellings have been made by the villagers from time to time, cattle of all kinds have been allowed to graze, but no fires have apparently occurred for five or six years. The state of reproduction in this forest is most satisfactory, the whole area being thickly covered with seedlings of all ages, and it is with the greatest difficulty that the neighbouring "zemindars" prevent the trees from invading their fields. From the above remarks I hope it will not be inferred that I approve of cattle grazing in all kinds of forest in general, and deodar in particular, but only mean to point out that we have apparently commenced the treatment of deodar forests, at all events, on a wrong system, which should now be corrected.

In fact the principle that each kind of forest should be treated separately, according to its peculiar circumstances and conditions, appears to have been somewhat lost sight of in this particular instance; and forest officers seem to have forgotten the fact that one sweeping rule with regard to grazing is by no means applicable to the whole country generally. In conclusion, I have no doubt that several of your readers who have had to do with the closing of deodar forests have been occasionally slightly embarrassed by the remark of the somewhat observant "zemindar," who, after the forest officer has enlarged on the absolute necessity of excluding the village cattle from the neighbouring deodar forest, has called the sahib's attention to the fact that, notwithstanding constant

grazing and occasional fires, numerous seedlings have sprung up, and the forest probably increased in area all the same, under which circumstances he finds it difficult to believe in the sahib's scientific arrangements.

E. McA. Moir,
Dy. Consr. of Forests, Tons Divn.

Iron Smelting.

THE Vienna Mining Journal (*Oesterreichische Zeitschrift für Berg und Hutten wesen*) of the 12th August contains an interesting account of successful iron smelting in Sweden by a new modification of the direct charcoal process.

The great drawback of all methods of direct iron smelting is the interruption of the process which is caused by the removal of the blooms. This has been much reduced by the following combination: A cylindrical shaft receives a continuous supply of the ore and charcoal which pass down through it. A small portion only of the fuel is consumed in the shaft, and the ore is all perfectly reduced to metallic sponge. Some red hot mixture of reduced ore and charcoal is at intervals withdrawn at the base of the shaft, and brought directly into a hearth. The air blast of the hearth, by the aid of the remaining fuel, melts the sponge into a solid bloom of wrought iron. The hearth is a closed one, so that all the time the gases from the hearth can pass into the above-mentioned shaft, and thus aid in the reduction of the ore. The withdrawal of the blooms from the hearth causes no interruption of the reduction, as it is intended to work two hearths at a time in connection with one shaft.

Whilst one hearth is separated from the shaft, the other will supply the gases, and *vice versâ*. The chief feature in the results is the almost complete extraction of the iron from the ore. The total loss of iron amounted only to 5 per cent. At the same time the consumption of fuel was moderate; 100 kilogramme of blooms required only 0·8 cubic metres of charcoal. This I take as equal to about 200 kilogrammes, which is half the quantity used by the other description of direct processes. (See my notes on the manufacture of iron, etc., in India, June 1881, page 4). More than this, the quality of the iron was found very good in spite of phosphorus being present in considerable quantity in the ores, which were magnetite, containing 60 per cent iron and 0·9 per cent phosphorus.

H. WARTH.

The Chrysanthemum.

THIS favourite of English conservatories has, of last years, established itself in Indian gardens. We cannot as yet boast of the many beautiful varieties possessed by our countrymen at home; however a fair number of good varieties of all the principal colours are to be met with. I have been unable to trace who first introduced the Chrysanthemum into this country. Mr. Fortune was the first to send to England from China the Chusan Daisy, the plant from which the dwarf small-flowered pompons have originated. He also sent the large-flowered Japanese variety. The section known in nurserymen's catalogues as large-flowered (*Chrysanthemum sinense*) was introduced into England as early as 1764. Many hybrids have been raised between the Japanese and Chinese large-flowered varieties; and I have no doubt both originated from the same wild stock. These hybrids have found their way to this country from England,—hence Mr. Fortune may be said to be the first to credit with thanks for a plant that has done so much to beautify and enliven our gardens during one of the most flowerless periods of the year.

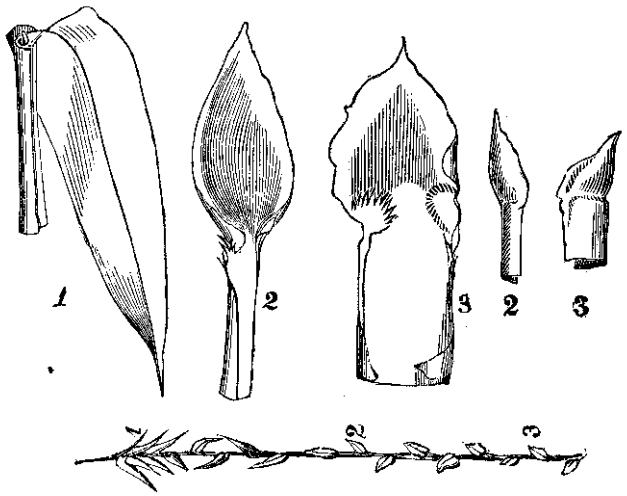
The cultivation of this plant is simple and easy. The climatic conditions of India will not allow us to raise the fine large specimen plants to be seen at Chrysanthemum Shows at home, but with a little trouble and care we can raise a plant that will greatly enliven the appearance of our gardens when in flower. It flowers in this country at the same time as in England, *viz.* from November to December. After the plants have flowered they ought to be cut down close to the ground, and watered as usual. About the middle or end of January the crown will begin to throw up numbers of young shoots. In England as a rule these shoots are separated from the old crowns and made into cuttings. The old crowns are generally thrown away, and the cuttings are grown into the flowering plants required for the next season. In this country, where the same method is followed, failure is the usual result. Cuttings, made from soft young shoots, do not strike root readily, and when they do succeed, the plants as a rule are weak and not able to withstand the damp of the rainy season. I find that the best method of propagation is to divide the old crowns in February, into pieces with three strong healthy young shoots attached; pot them in six-inch pots in a mixture of one part good garden soil, one part sharp river sand, and two parts old decayed leaf manure; place in a semi-exposed spot, and water regularly. The plants, if properly cared for, will attain a height of twelve to fifteen inches by the beginning of May. When they have attained that height, the shoots should be pinched back to within five or six buds from the ground. They will make very little growth during the hot season, but this is no disadvantage. As soon as

the rains set in, they will start into growth; and when well started, and after a few good showers have fallen, they should be repotted into twelve-inch pots. This time old cow or horse manure should take the place of leaf manure, there being now no danger of the manure heating and killing the plants. After the operation of potting, they will continue to grow until September. From the latter end of this month, and until the buds begin to open, a watering twice a week, with any kind of liquid manure, is very beneficial. When the buds are well formed, and if large show flowers are desired, the small side buds may be picked off, and only the large centre ones allowed to remain. If the treatment I have described be carefully followed, the resulting display of flowers will amply repay for all the labour bestowed.

W. G.

Bamboo Spathes.

TO THE EDITOR OF THE "INDIAN FORESTER."



SIR,—Regarding the collection of leaves or spathes of our bamboos, I once started collecting for Mr. Kurz, but found a serious difficulty *re* the spathes at the very commencement, *i.e.*, they often differ more conspicuously in form on the one single stem than in different species. Thus the spathes of our jati below on the young stem shoot are as in 3, while those at say three-fourth of the way up are much longer, as in 2, and those at the summit as in 1, are so very like ordinary leaves, that if it were not for the lower part one would take them for leaves. In the plate above they are shown on the culm and opened out.

Query is, which is the type?

Perhaps you can say if the lower ones only or mid stem are taken, they all have very decided differences. Perhaps those about X would be best.

I cannot find anyone who knows of any of these játis in flower. But natives do not, as a rule, observe very closely unless there is some special reason, and then they often beat us as in telling the various kinds of paddy, &c.

S. E. PEAL.

Notes on Cinnamomum Cassia, and the vegetation of the West River.

By Charles Ford,

Superintendent, Botanical and Afforestation Department, Hongkong.

Dr. Schlich has kindly lent us a copy of Mr. Ford's notes on the *Cinnamomum cassia* which yields the Cassia Lignia of commerce. At the instance of Sir Joseph Hooker, who wished to identify the tree yielding the Cassia Lignia, Mr. Ford proceeded last May from Hongkong up the West river to the Cassia districts, whilst the trees were in flower. He brought back about 1,700 young Cassia plants, many of which are available for distribution to other colonies; but states that, like most of the order of Lauraceæ the seeds must be sown very shortly after they mature, as they rapidly lose their vitality.

The largest tree he met with was about 40 feet high, with a trunk about 3 feet in girth, and said to be 50 years old. He gives a complete botanical description of the species, and remarks that the bark, leaves, and incipient fruit "buds" of commerce taste strongly of cinnamon. The tree was nowhere

met with in a wild state, nor could any native be found who could tell where it grew wild.

Although still largely cultivated, it is said that the Java Cassia trade, in consequence of low prices, is crippling the China trade. An interesting account is given of the nurseries and plantations, the latter being always on hilly ground at altitudes from 300 to 1,000 feet above sea level and at all aspects. One and two-year-old seedlings are used for the plantations, and are put out at distances 3 feet apart.

The climate of the Cassia districts has a mean monthly temperature varying from 55° in January to 85° in July, and a monthly rainfall from 0 to 3 inches in December, January, and February, gradually increasing to from 15 to 30; in the five months, from May to September, the annual rainfall being between 66 inches and 111 inches. The climate thus resembles that of Assam, where Cassia cultivation would probably succeed. The first crop of bark is obtained when the trees are about six years old, the season for barking continuing from March till the end of May, after which the natives say it loses its aroma. The stems are cut close to the ground, and conveyed to adjoining sheds. Here all the small twigs and leaves being removed and taken off, the bark is stripped off in pieces 16 inches long and the epidermis separated from it by a small plane. It is then left to dry for about 24 hours, and then tied up in bundles ready for sale. The leaves are carefully preserved and dried, and yield Cassia oil. Cassia buds are really immature fruit, and, as well as the seeds required for the nurseries, are obtained from trees ten years old and upwards, which are left standing at distances from 50 to 100 feet apart amongst the stool shoots. Plantations of Cassia thus form a six years coppice with standards, and the yield is said to be about three dollars per acre per annum.

The value of the export from Canton in 1881 was about 450,000 dollars.

Mr. Ford's notes on the vegetation of the West river are very interesting, and we give them in his own words:—

"The West river proper is not reached until about 20 miles have been traversed from Canton by way of Fatshau along one of the waterways of the great delta. For this distance, and the next 15 miles of the West river, *i.e.*, as far as the Shui Hing Pass, the lands on both sides of the river is alluvial soil well cultivated. The first part has extensive tracts of rice fields surrounded with banks, on which are grown litchi, longan, and peach trees, with, at the base of the banks, the water cedar, *Glyptostrobus heterophyllus*. On approaching Fatshau the mulberry tree is met with in fields where it is grown for silk worm feeding. After passing Fatshau the rice fields are replaced with mulberry trees and bamboos, the land being higher than the river, and incapable of irrigation. On rising ground near the villages there are magnificent patches of arborescent

vegetation, consisting of *Ficus retusa*, *F. Wightiana*, *Fraxinus chinensis*, *Bombax malabaricum*, and bamboos. The Soy beam, (*Soja bispida*,) hemp, and the ground nut *Arachis hypogaca*, are cultivated on dry sandy soil. At forty miles from Canton the hills approach the river, and form the Shui Hing Pass. A few miles to the east of this Pass are the Ting U Shan woods which contain some splendid trees, probably upwards of 150 feet high. Amongst them were noticed *Bischoffia javanica*, *Cinnamomum parthenoxylon*, *Sterculia lanceolata*, and *Pinus sinensis*. Those woods surround a fine monastery, and are protected by the priests. The frutescent vegetation here consists of well-known plants that are common in South China. After passing the Shui Hing Pass the hills again recede and leave a large plain, on which, in addition to those plants mentioned as cultivated on the alluvial soil, the other side of the Pass, maize is grown in summer, and wheat in winter and spring. *Euryale ferox* is also grown for the sake of its seeds, which are used as food by the Chinese. After leaving this plain, the hills approach the river, and leave only a narrow strip on each side for cultivation. On the steep hills are some large patches of *Gardenia florida*, cultivated for its capsules, which furnish a dye used for dying silk. Near the Gardenia plantations are also some of *Machilus velutina*, grown for the sake of its bark, which contains a glutinous substance used in the manufacture of joss sticks. *Camellia oleifera* is grown on barren hills in the vicinity of some villages to supply the growers with oil for cooking and anointing their heads. It is not grown in sufficient quantities to sell.

A little above, a town called Fung Chun, over one hundred miles from Canton, the narrow strip of land on the south bank of the river is planted with bamboos, which are extensively used for boat poles and scaffolding. These plantations continued, with but slight interruption, for about the next 100 miles.

On both sides of the river the country is very mountainous, the hills rising from 300 to 2,000 feet, and with the exception of the level strips bordering the river, and a few patches on the hills of *Gardenia*, *Machilus*, tea plants, upland rice, and pumpkins, are entirely destitute of cultivation. There is very little grass on the hills, but ferns (*Gleichenia dichotoma*) abound and cover the ground in every direction. The fern is cut and dried and used extensively for fuel; even the limestone in the lime kilns, which are numerous, is burned with this fuel only.

No forests are seen anywhere, but the Chinese are very careful to keep up, by annual sowing and planting, a stock of firewood, which however is confined to the common pine. *Pinus sinensis*, and instead of presenting the appearance of plantations well filled with handsome trees, they are planted irregularly and thinly over the hills, and have, in most

cases, but a miserable, stunted appearance, in consequence of the custom of continually cutting off the branches as they are required for fuel. Far up the river the *Cunninghamia sinensis* is found sparingly mixed with the pines, but this also never seems to attain a great size in the parts visited. *Cunninghamia* however, I was told exists in forests further north, and this report seemed confirmed by the enormous rafts of China fir logs, which were being floated down the river. The indigenous tree and shrub vegetation is continually destroyed, as it attempts to grow, by the deplorable custom of the Chinese in cutting down every branch and sapling for firewood, the *Pinus sinensis* being the only tree which they attempt to renew by planting. Round the villages and temples the trees are protected, and these examples, especially the Ting U. Shan woods, demonstrate the possibility of the Chinese mountainous districts producing splendid forests of a great variety of trees, if they were properly conserved.

No system of forestry seems to exist anywhere, the only efforts in that direction being the promiscuous planting and cutting of pines for firewood, this being done in the same way as on the mountain and islands near Hongkong—any one being allowed to plant where he likes, and the Government exercising no control over the people, in either planting or cutting down.

Fruit trees are only grown in small numbers dotted about near the houses, except the *Zizyphus jujuba*, of which a great many orchards were seen; they are on the level ground near the river, and the trees were planted at distances of about 20 feet apart. In addition to these, one orchard of litchis on a hillside was seen."

From Mr. Ford's description, we see that China is ahead of India in the matter of fuel plantations, and that doubtless the cowdung is put to its proper use as manure.

THE INDIAN FORESTER.

Vol. VIII.] DECEMBER 1882.

Notes for a Manual of Indian Sylviculture.

(*Continued.*)

General Remarks.

It will be apparent from the foregoing considerations that a mixed crop, which consists of trees of one and the same age, must, in most cases, become gradually either more or less pure, or differentiated into groups, each composed more or less exclusively of a single species. This species may be the one most suited to the given soil and locality; but it is not necessarily that one, and provided that both those main factors of production are sufficiently favorable for its prosperous growth, it is essentially that species which is the most tenacious and exclusive of the crop. Its tenacity will depend on the resistance it offers to the causes of injury described under Condition III, on its ability to live under shade, on its greater longevity, on the depth to which its roots penetrate, and on the greater facility with which it grows up again from the stool and throws up root-suckers; its exclusiveness will be due to the greater suitability of the soil, subsoil and locality for its growth, to the greater density and more favourable shape of its crown, to its capability of pushing up through the crowns of other species, to its greater rapidity of growth, to its superior stature, to the greater facility with which it shoots up again from the stool and throws up root-suckers, to the longer duration of its foliage and the season at which this is shed or renewed, and to the invasive spread of its roots or underground stems. The conclusion to be drawn is obvious. If our object is to raise mixed crops, we know that, as a general rule, we cannot secure a favorable and permanent mixture by having them of uniform ages throughout.

For further observations connected with this subject the student is referred to the general remarks under the Fourth Case.

Examples of the Third Case.

Instances of this Case are furnished by many mixed khair and sissoo forests, mixed tamarisk and babul forests, copses in which no standards are left, &c. Artificially raised forests coming under this head are very rare in India.

SECTION IV.—FOURTH CASE.—*Mixed crop composed of individuals of all ages.*

We have already seen that in a mixed crop consisting of trees of one and the same age, the consideration of the circumstances which decide the struggle for existence is extremely complicated, and that none of them can be examined apart without having to take into account the effects of some other or others. Under this head we have one more cause of complication, *viz.*, the existence of various ages. This circumstance influences more or less the working of nearly all the rest. The best plan is, therefore, it seems to me, to repeat all the headings of the Third Case, and consider under each what qualifying effect the difference of ages produces. Before proceeding to do so, I may say once for all that where no qualification is made, whatever has been said under that Case holds absolutely true also in the present one.

I. INNATE VIGOUR.—The comparative innate vigour of a plant will depend to a very great extent on its age. The natural sal seedling makes little head in the forest until its gradually increasing vigour enables it to make a sudden start when it is several years old; whereas its companions, the *Tetrantheras*, push up rapidly soon after they germinate. In the same way the two or three-year-old *Pinus excelsa* will grow up as vigorously as a deodar several years older. In many forests of the Central Provinces teak will remain only about a foot or two high until it is about twelve years old, when it will at once make a rapid start upwards. And so at a later age the vigour of one species will diminish earlier than that of another. In other and more general terms, the innate vigour of a tree will depend very much on its age, and greater age will not always be an advantage in the struggle for existence.

II. GREATER SUITABILITY OF SOIL AND SUBSOIL.—For one and the same species the unsuitability of a soil or subsoil increases with advancing age. Hence in the case of a soil that is well suited to only one of two species growing on it, the other may have a start of several years, and yet be ultimately overtaken and outstripped by the first. Here also read the remarks under Condition II of the Second Case.

III. DEATH, DISEASE, UNHEALTHY STATE, OR RETARDATION OF GROWTH BROUGHT ON BY CAUSES EXTRANEOUS TO THE FOREST, VIZ.:—

(*a.*) *Attacks of insects and other animals.*—The presence of old and decaying trees will cause a multiplication of insects, which may also injure to a less or greater extent the younger trees, and also individuals of other species. On the other hand, young seedlings of shade-bearing species will be protected against the ravages of deer, cattle, &c., if they spring up in the midst of a dense older growth of other species not touched by those animals.

As regards man, the presence of trees of different ages and different species is often a guarantee that the timber-dealer will, because they do not suit his purpose for one reason or another, spare many individuals of each species, which will then survive long enough to become the parents of a younger generation. The most casual visit paid to forests containing teak, sal and deodar, the most valuable of our Indian trees, will prove this.

(*b.*) *Attacks of parasitic and epiphytic plants.*—There is nothing new to add here after what has been said under the same head under the Third Case.

(*c.*) *Damage caused by climatic influences.*—Against frost, drought, and sunstroke the shelter of older trees of hardy species is often indispensable, and is always useful, to the permanence of other species that are delicate in their youth. In the torrid valleys and plains of Rajputana, nearly every nim tree springs up out of a Euphorbia bush; and, similarly in the Dehra Dun, nearly every tea bush has one or more toon plants growing up through it, so that a tea garden left to itself would soon degenerate into a pure toon grove. In the Changa Manga Plantation mulberry has possessed itself of the ground under the original sissoo. In creating a new forest where there has been none recently, it is often found necessary to raise at first a crop of a hardy species, under the shelter of which more valuable, but less hardy, species are afterwards introduced.

(*d.*) *Damage caused by fire.*—A crop consisting of trees of various species and different ages forms, as a rule, a denser growth and leaf-canopy than any other, and is hence exposed to less risk from fire.

(*e.*) *Floods.*—For the same reason a mixed forest of trees of different ages will generally offer more resistance to the violence of a flood.

(*f.*) *Injuries caused by felling, conversion, and export operations.*—As a rule it is the older trees that are felled. Hence there is seldom, if ever, any danger that the timber-dealer will make a clean sweep of an entire crop. The younger individuals left, consisting for the most part of seedlings, saplings or every small poles, will in most cases successfully resist all such injuries.

(*g*). *Climbers.*—There is no addition to make to what has been said under the Third Case.

IV. DENSITY OF THE LEAF-CANOPY; RELATIVE DENSITY AND SHAPE OF CROWN, AND RELATIVE CAPABILITY OF PERSISTING UNDER OR PUSHING UP THROUGH COVER.—All that can be said here has already been anticipated under the same Condition of the Third Case. I may, however, make a single additional remark. When a tree attains maturity, *i.e.*, reaches the point beyond which it begins to decline, the twigs and branchlets that develop every year

become fewer and weaker, especially in the upper part of the crown, where the branches gradually lose their vigour and, in some instances, die off. Meanwhile the lower branches continue to lengthen. The result is that the crown assumes year by year a rounded or flattened shape at the summit, and the foliage becomes everywhere increasingly spare.

V. RELATIVE LONGEVITY.—Younger individuals of some otherwise favorably circumstanced species may outlive trees of other kinds possessing greater longevity, thus enabling that species to maintain itself permanently in the crop in spite of inferiority in this respect.

IV. RELATIVE RAPIDITY OF GROWTH.—As said before, some species have their period of rapid growth early in life; others later. Hence young individuals of the former class may outstrip older trees of the latter class, and prevail in the end. But, on the other hand, these latter may be old enough to have entered upon their phase of rapid growth, and thus maintain the start they originally have in spite of disadvantages in other respects. As the relative ages of the trees of the several component species generally vary from point to point, the one result may follow as often as the other, thus guaranteeing the permanence, although in very different proportions, of all the species in question.

VII. RELATIVE MAXIMUM HEIGHT ATTAINABLE.—Age can obviously exercise no influence on this Condition.

VIII. RELATIVE SUITABILITY OF CLIMATE.—As under this Condition I have considered only the influence climate exercises on the general growth of one species taken in its entirety as compared with the similar influence it exercises on another, the question of age does not in any way affect the remarks already made under this head under the Third Case.

IX. SEEDING.—Under the Third Case this Condition was considered under six subheads, which were denoted by means of successive letters of the alphabet. Here we are obviously concerned only with subheads (*a*), (*b*) and (*c*), *viz.*, the relative abundance and frequency of seeding, and the relative vitality of the seed.

(*a*). *Relative abundance.*—A tree becomes fertile long before it has attained its full size and spread of crown, and remains so up to the moment of its natural death. With the majority of our species, the quantity of seed produced increases with the age of the tree until decline sets in, when it gradually diminishes as the crown contracts and becomes more and more spare from year to year. From this age onwards the fruitfulness of the tree generally diminishes rapidly. With individuals of different ages and species mixed indiscriminately in the crop, at every point will be found a tree of one species or another in more or less full bearing, so that every species will be represented by some individuals at least which can

perpetuate it in the crop, thus guaranteeing a permanent mixture of some at least, if not all, of those species.

(*b.*) *Relative frequency.*—In the case of those species which seed in a general manner only after an interval of two or more years, it is not uncommon to find some individuals here and there seed during that interval. Thus *Dendrocalamus strictus* flowers sporadically every year. Again, in Nimar, in the Central Provinces, *Hardwickia binata* flowered gregariously in 1873, not at all in 1874 and 1875, sporadically in 1876, and again gregariously in 1877. As a rule, the individuals that flower thus sporadically are among those which possess the least vital energy (this seems especially to be the case with *Dendrocalamus strictus*). Such individuals are generally the older ones. Hence it is an advantage for a species, which seeds only at long intervals, to be represented by at least a few old trees, which extraneous circumstances do not prevent from flowering and bearing fruit.

(*c*). *Relative vitality of the seed.*—As a rule old or very young trees produce seed, the vitality of which is more easily destroyed than that of seeds furnished by vigorous trees of middle age. Hence a species may be weak in numbers, and yet comparatively strong enough, from being represented chiefly by individuals of middle age, to be able to perpetuate itself.

X. RELATIVE FACILITY OF GROWING UP AGAIN FROM THE STOOL.—All trees that are able to grow up again from the stool lose this faculty after a certain age, varying with the species, has been reached. During the first years this faculty is slight, then increases rapidly, remains stationary for a few years, and, lastly, gradually diminishes. Hence where clearings or fellings on an extensive scale are made, the next crop may consist of species which are not necessarily the most fitted for the struggle for existence; those most fitted for this struggle may be represented chiefly by old trees past their coppicing age, while the rest have also numerous young individuals in the original crop felled.

XI. RELATIVE FACILITY OF THROWING UP ROOT-SUCKERS—The faculty of throwing up root-suckers is at first *nil*, then increases with the spread of the roots until the tree begins to decline, when the principal roots themselves gradually weaken and die off at their extremities.

XII. RELATIVE DURATION OF FOLIAGE, AND SEASON OF ITS FALL AND RENEWAL.—It is a general rule that within the same species very young individuals retain their foliage longest, and old ones for the shortest time; and that, if by any cause the foliage of the season is destroyed, the young (not always, however, the very youngest, since they are poor in dormant buds) individuals renew it earliest.

XIII. GRADIENT.—As the effect of gradient is rapid and effective drainage, it follows that on naturally dry slopes plants of a certain age and strength are more secure against fatal

injuries than very young ones with short and superficial roots.

XIV. RELATIVE DEPTH TO WHICH THE ROOTS PENETRATE.—The only effect that age has on this Condition is, that up to a certain period in the life of a tree the length of the roots is proportionate to its age.

XV. RELATIVE QUANTITY AND SPREAD OF THE ROOTS (INCLUDING THE RHIZOME).—The quantity and spread of the roots increases progressively with age until decline sets in.

XVI. A CLIMBING HABIT.—It is only after the first few years, when the young plant is thoroughly established, that a climber begins to nutate or throw up shoots which develop tendrils. Once this period is reached, age has no further effect as far as the climbing habit is concerned.

XVII. AN ARBOREAL HABIT.—This is a new Condition. An arboreal habit necessarily supposes the existence of different ages. Plants possessed of this habit are either (i) parasitic, like *Cuscuta*, fungi, &c.; or (ii) only partially parasitic, like *Viscum*, *Loranthus*, &c.; or (iii) purely epiphytic, like some figs, *Araliaceæ*, &c.

Parasites and epiphytes generally have already been taken account of under Condition III (*b*) as injurious "causes extraneous to the forest." In this place we have to deal with only such plants as form an integral portion of the forest, and have to struggle against others for a place in it. Under this category come only some of the species falling under class (iii).

In the case of trees with an arboreal habit, which, like the figs, become terrestrial as soon as their roots reach the ground, the epiphyte is bound to prevail over its temporary host, the stem of which is gradually strangled by, and in the majority of instances englobed within, the mass of roots thrown down by the latter.

The epiphytic *Araliaceæ*, nearly always also of climbing habit, do not, as far as I know, kill their hosts, but only weaken and deform them, in very much the same way as climbers do.

Readers of these Notes are requested kindly to supplement the preceding very incomplete remarks with the results of their own varied experience.

General Remarks.

From what precedes it will have been gathered that a mixture of different ages is favorable to the maintenance of a mixture of species. We have already seen that uniformity of age throughout a mixed crop tends to reduce the number of species, and, in most cases, to give an easy preponderance to a single one, the most tenacious and exclusive of the original mixture. So that the converse is also true, *viz.*, that difference of ages always promotes a mixture of species, and is often an

indispensable condition for growing a mixed crop: it gives a certain chance of existence to species which would otherwise be driven out by their more tenacious and exclusive companions. It requires only a cursory examination of a sal forest to convince oneself of the truth of this proposition. Where the trees are all of a more or less uniform height, and, therefore, presumably of about the same age, they are almost exclusively sal; whereas, where ages vary, many other species will be found associated with the sal, the relative proportion of those species generally increasing with the difference of ages. There can be no doubt that the pure character of the extensive teak copses of the Central Provinces, Berar, and Bombay are, in a great measure, due to a certain degree of uniformity of ages; it will generally be found that the purest of these copses are those in which the trees are pretty nearly of one and the same height.

Examples of the Fourth Case.

Instances of the Fourth Case are to be found everywhere in India. As some of the more important I may point to the majority of our teak and oak forests, to a great many sal and deodar forests, to our evergreen forests, &c.

SECTION V.—*Summary reasons why certain species are gregarious and others sporadic; and why some of these latter may, under special circumstances, become gregarious.*

From the considerations developed in the preceding sections, it will have been observed that a *gregarious* species is one which overcomes all others in the struggle for existence, and thus "has a tendency to form more or less extended masses of pure forest" (*vide* definition, p. 4). Such are sal, sissu, babul, the tamarisks, *Boswellia*, khair, *Mesua ferrea*, *Pinus longifolia*, &c. A study of the habits and requirements of these species will clearly explain why they are gregarious. By way of example for the student, I will select some of these species, and briefly give the characters which combine to render them gregarious. To enter into and discuss these characters in a full manner would carry me beyond the limits laid down for BOOK II of our MANUAL.

Sal.—This tree disappears the moment it reaches soil, the drainage of which is impeded. Its gregariousness is due to a great number of causes, some of which alone would be sufficient to give it an easy predominance over all other species in the soils which alone it affects. These causes are—

(*a.*) Perfect suitability of the soil which it generally occupies, so that, as a rule, it either flourishes in all its vigour or is completely absent.

(*b.*) Its nearly general immunity from the teeth of cattle.

(*c*). Its comparative freedom from parasites.

(*d*). Its comparatively easy recovery from injuries caused by timber operations.

(*e*). Its greater density of crown as compared with most of its associates of the same stature as itself.

(*f*). Its ability to form by itself a complete leaf-canopy.

(*g*). The ability of its young plants to persist under and push up through fairly dense cover, this latter faculty being considerably strengthened by their long, narrow crown.

(*h*). Its great longevity, exceeding that of nearly all its companions.

(*i*). Its relatively great rapidity of growth, after a certain age has been reached, right up to its attaining its full height.

(*j*). Its loftier stature as compared with nearly all its companions.

(*k*). Its comparatively great resistance to extreme temperatures, provided the rainfall and the relative humidity of the atmosphere are high enough, without the latter being sufficiently so to cause damp frosts.

(*l*). Its ability to grow almost equally well on all aspects within nearly* the whole vertical range of its distribution.

(*m*). Its profuse and all but annual seeding.

(*n*). The fall of its seed at the end of the season of forest fires, and at the beginning of the rains.

(*o*). The almost immediate germination of its seed.

(*p*). The great facility with which it grows up again from the stool.

(*q*). The persistence of its foliage during at least eleven months of the year.

(*r*). The great depth to which its roots can penetrate, enabling it to flourish even where the topsoil is waterless or the wind violent, and to escape strangulation during its early years by the deep vivacious network of roots of other species, like the grasses, &c.

(*s*). Its winged seed, enabling it, in spite of its great weight, to be wafted away a considerable distance from the parent tree.

(*t*). The production of more than one flush of leaves every year.

(*u*). The prompt appearance of a new flush of leaves, when the old foliage has been destroyed.

* In the very damp climate of Bengal and Assam sal, as I am informed, naturally prefers the drier southern and western aspects. In the drier climate of the Central Himalayas and of Central India, it grows vigorously on all aspects, and it is only at very high elevations, above say 3,500 feet, that a really decided preference for the warmer southerly and westerly slopes is manifested.

(*v*). The very remarkable facility with which a new leading-shoot is formed on the death or disappearance of the original one.

(*w*). The number of strong vivacious buds at the root-collum of its seedling, often enabling this latter to survive the severest fires, frost, drought, &c.

(*x*). The thick, sap-gorged bark, which protects the cambium and dormant buds from external injurious influences.

(*y*). The great length of taproot developed by its seedling.

Sissu.—This tree, as a gregarious species, is confined to the shingly and loose silty deposits in the beds and on the low and frequently flooded banks of Himalayan streams, where they debouch into the plains, spreading out over a great width and often branching into a number of shallow arms, which embrace between them islands of various sizes. The loose open soil, from being for a time flooded, occasionally dries down to a depth of as much as twenty feet, if not more. The gregariousness of the tree is, of course, due chiefly to the nature of the soil and situation in which it delights; but a number of other causes also contribute in their respective degrees to the same end. All these various causes may be thus summarized:—

*(*a*). The exclusive character of the soil and locality which the sissu affects, khair, *Zizyphus* and a few other species being alone able to grow there in appreciable numbers.

(*b*). The general infrequency and but slightly injurious nature of forest fires in sissu forest.

(*c*). The great resistance of the tree to floods.

(*d*). Its extremely easy recovery from injuries caused by the wood-cutter and timber-exporter.

(*e*). Its ability to bear a good deal of shade and form a dense thicket while young.

(*f*). Its comparatively great longevity.

(*g*). Its great early rapidity of growth.

(*h*). Its ability to stand extreme temperatures, including the dampest frosts.

(*i*). Its profuse annual, rarely biennial, seeding.

(*j*.) The remarkably easy transportability of its seed by wind and water, long submergence being unable to destroy its vitality.

* It would be very useful to know exactly the respective conditions under which khair and sissu form pure and mixed forests. No doubt some of the readers of these notes could supply the necessary information, for which they would deserve the best thanks of all Indian Foresters. Mr. Lowrie has drawn my attention to the fact that in the Saharanpur forests sissu gradually disappears as the amount of soil increases, being replaced by khair. This is not entirely borne out by my observations elsewhere. Nevertheless it is unquestionable that sissu reproduces itself chiefly, if not exclusively, on loose sandy silt, before the soil begins to consolidate itself and cover itself with grass, while khair generally comes in after a certain degree of consolidation has taken place, and can, of course, reproduce itself on firm grassy land.

(*k*). Its extremely ready germination.
(*l*). The great facility with which the tree grows up again from the stool.
(*m*). Its remarkable tendency to produce extremely abundant suckers, and the extraordinary vitality of its roots.
(*n*). The persistence of its foliage almost throughout the year.
(*o*). The great depth to which the roots penetrate.
(*p*). Extremely early seeding.
(*q*). Its nearly general immunity from parasites.
(*r*). The immunity its roots enjoy from the attacks both of white ants and rats.
(*s*). The prompt appearance of a new flush, when the old leaves have been destroyed by any cause.

Pinus longifolia.—The *Pinus longifolia* is a hill tree and flourishes in the poorest and driest soils, being able to attain its finest dimensions even on loosely-cemented shingly formations several hundred feet thick. Individuals of it are found as low down as 1,500 feet, and fairly large patches of it are to be met with in the moist outer Himalayan belt, but it forms really large gregarious forests only in the intermediate and dry inner belts at elevations ranging from 3,000 to 5,500 feet. The reasons for this gregariousness may, in a general manner, be briefly stated thus :—

(*a*). The extreme dryness and poverty of the soil and subsoil, which this pine delights in, and which most other trees avoid, and the immense continuous stretches of such soil to be met with at the altitudes which suit the tree. This is the chief determining cause of its gregariousness.
(*b*). Its almost complete immunity from damage from the mouth of cattle, and from lopping for fodder, that great cause of fodder-yielding trees in the Himalayas being kept down in the state of low bushes.
(*c*). Its greater longevity in comparison with the majority of its companions.
(*d*). The greater relative rapidity of its growth, and the superior vigour of its leading-shoot.
(*e*). Its taller stature in comparison with that of its ordinary companions.
(*f*). The greater relative resistance of the young pine to frost and drought.
(*g*). Profuse general seeding at short intervals, with fairly abundant seeding in intermediate years.
(*h*). The small size of the pine seed, which enables it to be caught in the smallest crevices or hollows in the hill sides, contrary to what happens with acorns which roll or are washed down in numbers to the

bottoms of the valleys and ravines—the oaks, be it remembered, are the only trees among its usual companions that are at all able to compete with the pine in stature, while *Pinus excelsa*, deodar, and the firs, which are equally large or larger trees, do not flourish except where the altitude becomes too great for *Pinus longifolia* to grow as an exclusive tree.

(*i*). The greater relative vitality of the pine seed, and the small proportion of it eaten by animals as compared with acorns, which are frequently worm-eaten and are devoured in large quantities by bears, monkeys, &c.

(*j*). Easy transport of the seed by wind and in consequence of the steep gradients affected by the pine.

(*k*). The extremely ready germination of the seed.

(*l*). The ability of the tree to grow on the steepest gradients.

(*m*). The ability of the pine to form a more or less complete leaf-canopy during at least half its youth.

(*n*). The unfavorable and even injurious nature of the humus which its decomposed needles yield, grass and many other herbaceous and even some woody plants being kept down or driven out from under the pine by it.

(*o*). Its extremely thick corky bark, which enables the pine to survive the severe annual fires.

Anogeissus pendula.—This tree is a denizen of the dry and arid tracts of Central India, where it forms dense, almost pure forests on the metamorphic formations of the Aravali range and on the Vindhyan sandstones of Bundelkhand. It gregariousness is due to the following combined causes :—

(*a*). Perfect suitablity of the soil and subsoil and the climate, which admit of only a very poor arborescent flora.

(*b*). Relatively slight injury suffered from forest fires owing to its low, dense, spreading interlacing crowns, which permit of no undergrowth; and comparatively easy recovery from injury thus sustained.

(*c*). Extraordinary power of recovery from injuries caused by the wood-cutter and cattle.

(*d*). Marked tendency to join and interlace crowns.

(*e*). Greater longevity than that enjoyed by the majority of its companions.

(*f*). Larger stature than that attained by most of its companions.

(*g*). Greater relative rapidity of growth of its seedlings after a certain age has been reached, and of its stool-shoots almost from their very first year.

(*h*). Markedly greater relative resistance to severe frost and fierce heat as compared with most of its companions except khair.
(*i*) Profuse annual seeding.
(*j*). Easy transport of its small and winged fruit.
(*k*). Singularly greater relative power of coppicing.
(*l*). Persistence of foliage during ten months of the year, while its companions are leafless for several months.
(*m*). Ability to grow on the steepest slopes.
(*n*). Relatively strong development of roots.

Boswellia thurifera.—This tree is spread over the whole region of Central India. It grows gregariously as an upper crop on the dry trap and sandstone hills there, but forms an entirely pure forest where the amount of iron in the soil is marked. In this last case, the single circumstance of the soil being ferruginous excludes every other species. The causes which render the tree gregarious elsewhere may be shortly stated thus :—

(*a*). Dryness, poverty, and rocky nature of the soil, which prevents most of the few companion species from rising above mere undergrowth.
(*b*). Its complete immunity against the depredations of destructive animals, including in most cases also man, since the wood of the tree is generally despised even as a fuel.
(*c*). Its singularly great resistance to the destructive effects of forest fires owing to its thick sap-gorged, vivacious, exfoliating bark, and its extremely easy recovery from damage sustained thereby.
(*d*). Its markedly greater relative rapidity of growth from the very first years.
(*e*). Its much higher stature in comparison with most of its companions, the few individuals of *Sterculia urens*, *Odina Wodier*, &c., that grow with it, being excepted.
(*f*). Its immunity against the fiercest heat of the sun, and its great power of recovery from the effects of frost.
(*g*). Its conspicuous ability to withstand the most prolonged drought.
(*h*). The annual abundance of its seed.
(*i*). The very ready germination of its seed.
(*j*). Its unique power of coppicing, and hence of withstanding any degree of mutilation.
(*k*). Its faculty of producing abundant suckers, especially from the roots of felled trees.

Hardwickia binata.—This is a tree of the dry tracts of Central and Southern India, and also grows along the foot of the Kaimur Hills from Rewah to Hazaribagh. It is confined

to strongly silicious soils whatever their origin, and attains its finest dimensions on rocky rugged ground, even where there is scarcely a vestige of soil. It sometimes forms pure forests, but oftener occurs as a top-story over an open undergrowth of *Anogeissus latifolia*, *Boswellia*, khair, teak, &c. The causes which combine to make it gregarious are—

(*a*). Relative unsuitability of the soil and subsoil, which it affects, for its few large companions.
(*b*). Its immunity against attacks of parasites.
(*c*). Its great relative powers of recovery from the effects of forest fires.
(*d*). Its remarkable powers of recovery from mutilation by man.
(*e*). The ability of its young plants to withstand the low dense cover of the ordinary companion species.
(*f*). Its unique power of working itself up through the overhanging crowns of those species.
(*g*). Its greater relative longevity.
(*h*). Its greater relative rapidity of growth when once it is established.
(*i*). The greater height attained by it in comparison with most of its companions.
(*j*). Its great resistance to the severest dry frost.
(*k*). Its ability to withstand the fiercest heat of the sun.
(*l*). Its extremely profuse general seeding once in every three or four years.
(*m*). The easy dissemination of its seed to several hundred feet from the parent tree, owing to the flat light pod.
(*n*). The great vitality of its seed up to the first fall of rain.
(*o*). The great facility with which the seed germinates.
(*p*). Its remarkable powers of coppicing until it is about 40 years old.
(*q*). The persistence of its foliage during at least 10½ months of the year.
(*r*). Its producing more than one flush of foliage during the year, each accompanied with a vigorous development of new shoots, and the first occurring while most of the companion species are leafless.
(*s*). The remarkable length of taproot developed by its seedlings.

In the preceding examples I have endeavoured to show, without entering into any explanatory details, why certain Indian species are gregarious. The reasons given are sufficiently obvious after a perusal of the discussion of the four cases, under which the struggle for existence among the plants of a forest crop was studied. I will now make a further application of the principles therein exposed, and show (I), why in

certain tracts in Central India teak is gregarious, and (II), why it is everywhere else only a numerically weak denizen of mixed forests.

(I). The places where teak is gregarious are either (i) alluvial flats along the courses of rivers, or (ii) small stretches of stiffish sandy soil once under squatter cultivation, or (iii) hillsides, flats or stretches of undulating ground, which have for centuries been subjected to the *dhaya* system of cultivation already described on page 111.

(i). The soil in the alluvial flats referred to is more or less saline, with a strong proportion of carbonate and sulphate of lime, and is in many instances submerged for a few days during the floods of the rivers. It is, on the other hand, extremely dry and hard for several feet below the surface when the rivers have subsided into their normal beds during the hot weather. These characteristics of the soil exclude most of the ordinary companions of the teak—*Terminalia tomentosa*, *Anogeissus latifolia*, khair, *Boswellia thurifera*, *Pterocarpus Marsupium*, *Sterculia urens*, &c. The few associates that follow it, like *Morinda citrifolia*, *Eriolæna Hookeriana*, *Acacia leucophlœa*, *Ulmus integrifolia*, &c., being beaten by it in the struggle for existence owing to the following causes:—

(*a*). Its wonderful power of recovery from damage caused by fire.

(*b*). Its relatively great power of resistance to floods.

(*c*). Its enormous spreading leaves, which choked up every other forest seedling in immediate contact with them.

(*d*.) Its remarkable faculty, while young, of piercing through thick cover overhead.

(*e*.) Its conspicuously greater longevity.

(*f*.) Its more rapid growth almost from the first years, and continued up to its attaining its full height.

(*g*.) Its greater stature as compared with most of its companions.

(*h*.) Its profuse annual seeding.

(*i*.) The extraordinary vitality of its seed, which the annual floods only helped to disseminate and prepare for immediate germination from the time these silt-formed tracts were deposited.

(*j*.) The remarkable facility with which up to an advanced age it grows up from the stool, and the enormous strength and height of the stool-shoots in their very first year.

(*k*.) Its ability up to a certain age (certainly 40 years) to form of itself a complete leaf-canopy, capable of killing out all undergrowth, even including grass.

(*l*.) The size and nature of its fallen leaves, which, when rain falls, get glued together into a thick continuous felt-like covering over the ground, which covering

decomposes slowly, smothers up almost every seedling produced underneath it, and is impenetrable to the rootlets of most seedlings that germinate above it.

(*m.*) The existence of a more or less perfect uniformity of ages due to the greater portion of the crop having sprung up within the short interval of years, during which the alluvial flats in question were deposited.

(ii.) The gregariousness of teak in the second instance may be accounted for thus :—

(*a.*) Profuse annual seeding of the trees round and inside the original fields, by which means the ground got sown to a certain extent everywhere with teak.

(*b.*) The cultivation of the soil furnished this seed with an excellent bed, whence the production of a certain number of vigorous teak seedlings every year.

(*c.*) The great vitality of the seedlings produced, which by throwing up shoots every year from the collum of the root, gradually strengthened themselves, and which the mere annual scratching of the rude plough damaged scarcely or not all.

(*d.*) These seedlings were obviously still further strengthened in a remarkable degree by the hand-plucking of all surrounding grass and weeds, the agricultural crop alone being never dense enough to impede their development and the wandering squatter cultivator never finding their presence sufficiently hurtful to eradicate them.

(*e.*) The extraordinary vitality of the seed, which, lying in the soil in large quantities when the field was abandoned, produced an abundant crop of seedlings during the ensuing two or three years.

(*f.*) The great rapidity and vigour of growth of the already established seedlings and young stool-shoots which, on the fields being abandoned, suppressed most individuals of such of the companion species as were able to reproduce themselves, like the teak, during the course of the squatter cultivation.

(*g.*) See (*k.*) of the preceding case.

(*h.*) See (*l.*) of the preceding case.

(*i.*) The more or less uniform height of the various individuals, due to their having finally started upwards all together on the abandonment of the fields in question, and giving to the crop more or less the character of one consisting of trees of one and the same age.

(iii.) The gregariousness of teak under the *dhaya*

system of cultivation may be explained by the following causes :—

(*a.*) Its great power of recovery from the worst mutilation, even in spite of annual fires.

(*b.*) The great power of its root collum of producing shoots up to a very great age (eighty years at the very least.)

(*c.*) The extraordinary vitality of its seed, even when scorched by jungle fires.

(*d.*) In the case of hillsides, their ruggedness offered numerous crevices and hollows for the lodgment and germination of the seed falling or rolling down from above.

(*e.*) The great relative vigour of its stool-shoots, which enabled them to overtop seedlings and similar shoots of other species.

(*f.*) The extremely dense crowns formed by its huge spreading leaves tolerating no undergrowth, and pushing back and choking up plants of the same height as themselves.

(*g.*) See (*k.*) of the preceding case.

(*h.*) See (*l.*) of the preceding case.

(*i.*) The great longevity of teak.

(*j.*) The ability of its young seedlings to withstand fairly dense cover, thus allowing an abundant advance growth to come up gradually, which shoots away upwards as soon as it is uncovered.

(*k.*) The contemporaneous springing up of the new stool crop as soon as the *dhaya* cultivator departed for fresh fields.

It now remains to explain why, the three preceding cases excepted, teak should everywhere be a denizen of mixed forests. The causes of this may be briefly summarized thus :—

(*a.*) In forests which contain teak, the soil is apt to vary from point to point with regard to the proportion of clay in it, with regard to the degree in which the surface or subsoil rock is fissured, and with regard to the freedom of the drainage. Where the soil is too binding or not sufficiently drained, or too dry for teak, or the rock is too compact, that species will simply refuse to grow, and any seedlings of it that may germinate in such places are bound soon to disappear.

(*b*). Where the teak grows, it is almost the only tree of which the timber is used, furnishing, as it does, everything from the large house beam and broad boards to the thin round rafter of the rude temporary thatched shed.

(*c*). Its young seedling, although it stands a fair degree of

cover *overhead*, is soon killed by the *immediate contiguity* of dense growth (like that of the grasses for *instance*), *which exercises lateral pressure* against it on every side.

(*d*). A great many of the companions of teak are more shade-bearing than itself, some being conspicuously so.

(*e*). Many of its companions grow more rapidly than itself from their earliest years as seedlings.

(*f*). The young plant is extremely sensitive to frost.

(*g*). In many places several of its companions exceed it in stature.

(*h*). Its seed, being large, does not find easy lodgment in *the soil, and is exposed to be washed away during* the rains.

(*i*) Again, as the seed is all shed by the middle of the hot weather, the greater portion of it used every year to be destroyed by the annual forest fires before special protective measures, of very recent date, were undertaken.

(*j*). The seed germinates with difficulty, requiring throughout nearly the whole of India to lie for at least one year in the ground exposed to the alternation of damp *and drought*.

(*k*). The seed is the common food of many rodents, parrots, &c.

(*l*). The upper portion of the root of the young seedlings is greedily devoured by rats.

(*m*). The majority of the associated species retain their foliage longer, and bring it out earlier than the teak.

(*n*). After a certain age teak loses the faculty of forming a complete leaf-canopy by itself, thus making room for the admission of other species even where it originally formed a pure crop.

(*o*). Some birds, as the bush quail (*Perdicula asiatica* and *Arghunda*) devour the cotyledonary leaves as soon as they appear.

(*p*). The teak limits the spread of its roots and rootlets to within five or six feet of the surface, and, taken relatively to that of many of its companions, the mass of these roots and rootlets is small and far from invasive.

The preceding examples* suffice to show that the gregariousness or sociability of our forest species is nothing but

* It would be very interesting, and for me personally a matter for deep gratitude, if readers of these Notes kindly added a few more examples after the manner which I have followed. For instance, those having long experience of deodar might explain under what conditions it grows gregariously and when in mixture with a large proportion of other species. Foresters in Assam could tell us why *Mesua ferrea* generally forms pure forests. Those who know Mysore could tell us all about the Sandalwood. From Sindh we could have an explanation of the causes of the gregarious character of babul and the tamarisks.

the result of a struggle for very existence between two or more of them, and the consequent survival of the fittest. The fittest are, however, not always our most valuable trees, whether absolutely so or because they favour the growth of those which are; and we as foresters must, therefore, often intervene in the struggle and aid the weaker to conquer the stronger. Hence the most practical end intended to be served by the considerations developed in the preceding sections of the present Chapter is that they might furnish us with the key wherewith to study and analyse accurately the behaviour of each one of our more valuable species in that struggle, to note under what circumstances it can hold its own against all its rivals, under what circumstances it has to yield to its stronger neighbours, to what extent and how these latter circumstances may be favorably modified by the forester, up to what point the struggle is useful in drawing up the trees, in naturally forming their boles or in any other way improving their growth or the quality of their timber. Armed with such facts, we can, with the full confidence that knowledge begets, interpose with the most appropriate effective measures, as soon as the necessity arises, to shorten or prolong the struggle as the case may require, and to continually aim at securing the most advantageous proportion and distribution of the various species and age-classes—in other words, attain the very end and object of Sylviculture, which are the largest and most useful production in forests grown for the market, and the most effective tree-covering, combined, whenever possible, with a large and useful production, in forests grown for protection.

SECTION VI.—*Ought we to grow pure or mixed forests?*

As has just been said in the concluding observations in the immediately preceding section, the object of the sylviculturist, according as he is growing his forests for the market, or chiefly for purposes of protection, is to obtain either (*A*) the maximum and most useful production of which the soil is capable; or (*B*) the most effective living vegetable covering, combined, whenever possible, with a large and useful production.

§ 1.—*A. Forests grown exclusively for the market.*

To obtain the maximum production alone the following conditions must co-exist:—

(i). *The forest must be composed of the most suitable species for the soil and climate.*—Both these elements generally vary from place to place and often even from point to point, and the species must, therefore, vary accordingly, since there is no single one that will grow equally well under ever changing conditions of soil and climate. Hence advantage in a *mixture of species.*

(ii). *The forest should consist of the greatest number of stems possible at any given stage of growth.*—This is secured by con-

stantly maintaining as complete a leaf-canopy as possible—a result best attained by a *mixture of species* possessing different habits, different requirements as to soil, situation, and aspect, and a different ramification and spread of roots; besides, making different rates of growth, and reaching different statures.

(iii). *The trees should attain the greatest length of bole possible under the given conditions of soil and climate.*—This end also is best secured by a *mixture of species*, thanks to which the trees attain various heights, their crowns press one against another, and the depth of the leaf-canopy is always maintained at its maximum, the result being forcing in height and rapid elongation of the boles up to the maximum limit possible for each species.

(iv). *Continual improvement of the soil until its maximum fertility is reached, and constant maintenance of that maximum thereafter.*—To secure this end we must have—

(*a*). *An abundant annual production of foliage yielding a rich humus.*—Some trees produce more foliage than others, *e.g.*, sal and *Terminalia tomentosa* than teak; in the hills the oaks, deodar, and the firs than *Pinus longifolia*; and so on. Then, again, the leaves of some trees decompose more easily and form a richer humus than those of others: thus, for instance, *Terminalia tomentosa* and sal are better in this respect than teak; the oaks, than *Pinus longifolia* or any other conifer.

(*b*). *The, as much as possible, constant maintenance of a complete leaf-canopy, in order to protect the soil, including its covering of dead leaves*—

(*α*). *From the sun's rays*, which would dry up the soil rapidly and hinder the formation of humus;

(*β*) *From winds* which would blow away the covering of dead leaves, besides accelerating the evaporation of moisture from the soil;

(*γ*). *From the direct action of rain*, which would wash away the covering of dead leaves and humus, besides carrying away in abundance soluble substances fit for plant food;

(*δ*). *From (to a great extent) fire*, by keeping the layer of vegetable debris moist, and impeding the production of a strong draught of wind (in case a fire occurred) which would only fan up the flames;

(*c*.) *The prevention of fire*, which would, besides destroying all the organic matter in the topsoil, bake its surface hard.

All the objects mentioned under this fourth main head are most completely attained by means of a *mixture of several species*. If the species composing a forest are all, or most of

them, deciduous, some of them are sure, or at least very likely, to be in leaf, while the others are bare, and thus a green canopy (imperfect it may be, but nevertheless a green canopy) will be secured during as many months of the year as possible; whereas, when there is only a single species, and that a deciduous one, the whole forest may be leafless for a considerable time, and the soil completely exposed to injurious influences. Moreover, when several species grow together, they form not only a denser but a deeper mass of continuous foliage, the obvious consequence being a more abundant production of leaves, area for area, than if the forest were pure.

(v). *The forest must be protected against storms, fires, insects, hide-binding, snow-break, and many other causes of destruction or malformation of the trees.*—The closer the growth is, the less risk is there to fear from storms, fires, snowbreak, &c. *A mixture of species* produces the closest possible growth for any age, soil, and climate. Then, again, the denser the forest is, consistent with the healthy development of the trees, the less danger is there to apprehend from insects, and the less likely are the trees to become hide-bound. Here again a *mixture of species* is desirable. Besides this a mixture of species has still another advantage; as insects are sometimes selective, some of the trees are sure to be spared when the rest are attacked.

In order to secure, besides *the maximum production*, also *the most useful produce* of which the soil and climate combined are capable, the following additional conditions must exist simultaneously with all the preceding:—

(vi). *The forest must be composed only of marketable species, the largest proportion possible, if the forest is mixed, being assigned to the most valuable (principal) species, consistent with the realisation of all the other conditions.*—The necessity of this condition is obvious.

(vii). *The forest should, if possible, consist of a mixture of species.*—Mixed forests yield more varied and, therefore, more widely useful produce. Different industries require different descriptions of wood and other forest products, and our aim ought to be to satisfy all present and future requirements with the least amount of inconvenience and expense to the people. A judicious mixture of species is the surest means to this end.

§2.—*B. Forests grown for protection.*

Conditions (i), (ii), (iv), and (v), discussed in the preceding subsection, hold good here as *necessary* conditions; while (iii), (vi), and (viii) are *useful*, but not necessary. The forest should be composed of the most suitable species for the given soil and climate; it should contain the greatest number of stems possible at any given stage of growth; the soil should be continually improved and protected; and, lastly, the trees should afford

each other mutual security against all extraneous accidents. If in addition to this, the trees acquire the greatest length of bole attainable, are all marketable, and belong to various species, the forest, besides fulfilling in the most complete manner its special and original rôle of affording protection, will also furnish a large quantity of useful produce.

§3.—*Forests may sometimes be grown pure.*

From the considerations developed in sections 4 and 5 of the present Chapter, it is obvious that the raising of pure forests is to be generally avoided. Under certain special circumstances, however, forests *may* or *must necessarily* be grown pure.

It may be laid down as a general rule that a species *may* be cultivated by itself only when the following three conditions are realised at one and the same time :—

(i). *It should be able to form of itself a complete leaf-canopy up to an advanced age, certainly not much below that at which it becomes fully fertile;* for under no other circumstance would (*a*) the fertility of the soil be increased or maintained, (*b*) the natural pruning of the boles of the trees be effected to the desired extent, and (*c*) the forest yield anything approaching the maximum amount of produce of which it is capable.

(ii). *The effective factors of soil and climate should be uniformly favorable for its prosperous vegetation over a more or less considerable area.* Unless this area were absolutely large, the pure crop thus composed could scarcely be considered more than a mere patch of trees forming a small part of a much larger whole of truly mixed forest.

(iii). *The produce furnished by the given species should either be in such great demand that every square inch of the soil ought to be devoted to its cultivation, or possess such a high market value that the cultivation of any other species in mixture with it would result in an appreciable loss of possible revenue.*

These conditions would not unfrequently be realised in certain stretches of sal forest, in toon plantations on extremely favorable ground, &c.

Exceptionally a species, which does not satisfy the first of the three preceding conditions, *may* be raised pure—

(i). *When it is exploited on a very short rotation.*—During their youth all trees protect the ground well enough, since the young stems not only bear standing close together, but also possess low crowns almost reaching down to the ground. Teak coppice furnishes a good instance of this: under a full crop, say of from 800 to 1,000 stems per acre, not a single blade of grass can make its appearance. A bamboo brake is another excellent case in point.

(ii). *When the soil is such that its fertility is not impaired by a defective covering of trees.*—We may instance marshy land, to which the admittance of sunshine and wind is, in truth, benefi-

cial, and the bottoms of many valleys as well as many low-lying places, which always remain moist or wet in consequence of their situation, and where the soil is always deep, rich, and free, thanks to the humus and vegetable debris continually washed down on to it from the higher surrounding ground. Even on such soils, it is desirable that the single species chosen to be raised should be as shade-bearing as possible, so as to compose a more or less complete leaf-canopy.

It has just been explained under what circumstances a species may be grown pure. In the following case there is no alternative but to raise pure forests :—

When the soil is such that no other species, whether marketable or not, will grow on it; for example, the stretches along the Indus which tamarisk or babul alone can occupy ; along streams at the foot of the Himalayas, where sissu or khair only will succeed ; some of the laterite tracts in Burmah, where eng is the sole tree ; and so on.

One point in favour of pure forests is that their working is simpler than that of mixed forests, since there we have to study and satisfy the requirements of only a single species.

But it is especially and exclusively in the raising and treatment of those forests that this greater simplicity is marked, as will be clear after comparing together the considerations developed in the first four sections of the present Chapter. In revenge, when there is only a single species in the crop, the lines on which work must be carried out are necessarily very inelastic, and everything must be done with a more or less mechanical regularity, little scope being left for altering the system of management from time to time in order to suit the ever-changing conditions of the country and the market.

§4.—*Advantages of a mixture of species.*

In the subsections which precede, it has been shown that pure forests should be the exception, mixed forests the rule. In Sections 1 and 2 it was explained how every condition for obtaining the largest amount of the most useful production or the most effective tree-covering, combined, whenever practicable, with a large and useful production, was realised by means of a mixture of species. This is now the place specially to examine the advantages to be derived from growing mixed forests. They are briefly as follow :—

I. Mixed crops, as a rule, form a denser leaf-canopy than pure ones.—In a mixed forest some trees attain a large stature than others, have a differently shaped crown, are more or less shade-bearing, thrive better on certain soils and in certain situations, and so on. The leaf-canopy is hence composed of crowns of various shapes and sizes, and situated at various heights above the ground, and fitting into one another like the gravel and stones in concrete, thus generally forming a closer-

packed mass of foliage than if the forest were composed entirely of any single one of the same species as constitute the mixed growth. Now in every forest, whether pure or mixed, the number of stems standing must necessarily diminish progressively with advancing age by the death and disappearance of some of the trees. In a pure forest, unless the component species be extremely shade-bearing, the intervals thus produced between the crowns of the surviving trees are bound to become rapidly wider and wider, until at a comparatively early age the trees, all more or less of the same height, stand well apart from one another and cease to protect the soil except in a very incomplete manner. In a mixed forest, on the other hand, during a considerable part of its life, the gap produced by the disappearance of any of the trees will nearly always be filled up by the upward growth of those immediately below or by the extension of the adjacent crowns chiefly of individuals of other species. Hence the greater density of a mixed forest becomes more conspicuous with increasing age, and mixed crops, as a rule, maintain a complete leaf-canopy up to a more advanced age than pure ones of the same species—a very great advantage for the forester in many cases.

II. A judicious mixing of species increases the amount of ligneous production.—For the same reasons that the leaf-canopy becomes denser, the number of stems standing per unit of area at any age becomes larger. Besides this, the greater density of the leaf-canopy produces longer boles, and improves the soil, and hence prolongs the period of sound growth. All these circumstances result in a larger production of wood, and especially timber.

III. It is only by a mixture of species that with annual successive working we can cultivate our more valuable species in the greatest abundance, over the widest extent of country possible, and of the finest quality and size.—Many of our most valuable species, like teak, *Dalbergia latifolia*, *Lagerstræmia Flos-Reginæ*, &c., and in many localities even deodar and sal, grow naturally in company with other trees. If we sought rigidly to obtain pure crops, we must either clear away all these latter, and leave a few isolated individuals or patches of the former to form the sum total of the standing growth; or, if we insisted on having a full growth on the ground, we must cut away every individual of those valuable species where they could not grow gregariously, and restrict them to those places, of limited extent, and few and far between, where they could—the one result being as much to be avoided as the other. On the other hand, by studiously preserving and favouring the growth of every individual of our valuable species, whether it stands by itself or in company with others of its own kind, provided it does not interfere with the growth of another more valuable than itself, we

produce the classes of timber and wood most in demand in the largest quantity possible, and also spread their production over the widest extent of country possible, and thus raise them as near as possible to the consumer.

Then, again, as a mixture of species, by producing a denser *leaf-canopy, improves the soil, forms long and well-shaped* boles, and delays the commencement of natural decay, our valuable species are enabled thereby to acquire their finest qualities, and attain their largest dimensions. So that any of them, grown in company with a soil-improving species (*i.e.*, one which puts forth abundant foliage, that decomposes easily and yields a rich humus), will furnish timber of good size and quality even on soils on which it could not thrive by itself. Thus we know that sal, deodar, and especially teak, acquire much finer dimensions in mixed forests than when growing pure, and this most conspicuously on soils that are in themselves more or less unfavorable for their growth.

IV. A judicious mixing of species furnishes produce suited for a greater variety of purposes, and hence giving occupation to an absolutely as well as relatively large portion of the artisan class of the country.—This is especially so in advanced communities. We in India are still in a very backward condition. But the signs of the times are already encouraging, and in many parts of the country various woods, which only a few years ago no one would literally look at, are now coming into the market; while for some of them there is an established and rapidly increasing demand. In many parts of Berar and Central India the *Boswellia thurifera* is readily bought up at high rates in the shape of boards for flooring and packing cases, and as building wood, although about half a generation ago there, and at the present day elsewhere, the wood of that species was or is despised even as an occasional fuel. The timber of *Terminalia tomentosa*, which used generally to be a drug on the market, is now universally valued for railway sleepers. The formerly, and in many places still, despised *Pinus longifolia* is now exported in large quantities from the hills into the Punjab plains and passed off as deodar. In some parts of the Central Provinces, *Ougeinia dalbergioides* poles command higher prices than teak of similar size. In the vicinity of spinning factories *Zizyphus Jujuba*, which formerly served chiefly for fuel and fencing, is now in great demand for cotton mill spindles. Such examples may be indefinitely multiplied. We have in India unlimited resources for cabinet-making, the manufacture of matches, and other wood-using industries. Enterprise and time will soon show us how to employ them.

V. A mixture of species tends to increase the production of minor produce, such as seeds, fodder, &c.—As a rule, it is the young tender leaves of trees that are used as fodder for cattle. Now

in a mixed forest the various trees bring out their new foliage at different periods of the year, so that a more continuous supply of fodder is thereby assured. Moreover, in such a forest, some of the species, being of a low habit, or not being valued for their wood except as fuel, can often be lopped without any appreciable damage to the standing growth, and must even frequently be so lopped for the improvement of this last. Nay individuals of the more valuable species themselves must very often be cut out or lopped in order to favour the development of the rest.

This advantage, which I have numbered (*V*), is so obvious that it needs no further discussion.

VI. Many kinds of trees are less liable to damage in mixed than in pure forest from storms, fire, frosts, snowbreak, hide-binding, insects, game, cattle, and diseases in general.—In company with a deep-rooted species, another with superficial roots is able to resist storms almost as well as the former. Even superficially-rooted species protect one another when mixed, by reason of the denser leaf-canopy they form than when they grow pure. For the same reason the chances and destructiveness of fire are diminished in a mixed forest. This is especially the case in crops of mixed conifers and broad-leaved species as compared with those of conifers alone. In forests containing conifers the admixture of broad-leaved trees protects the former from snowbreaks to a very great extent, thanks to the support afforded to their branches by neighbouring individuals of those species. Then, again, as insects generally attack sickly trees (which are relatively not numerous in mixed forests), and often, if not generally, confine their depredations, when they attack healthy individuals as well, to a single or only a few species, their ravages are naturally not so extensive in mixed as in pure forests. And if the forests in question contain conifers, the companionship of broad-leaved trees is beneficial, as the numbers of the natural enemies of insects (birds, rodents, &c.) are generally increased by their presence. Again species, which in early youth are delicate, find much more protection against frost, drought, &c., in a mixed than in a pure forest. Another beneficial effect of mixture is, that it contributes very materially towards the diminution of diseases of which the attacks of fungi are either the symptom or direct cause. Lastly, trees, the leaves of which are eaten by cattle or deer, run less risk of being browsed down when they grow here and there mixed with other species than when they all stand together as they do in pure forests.

VII. The relative suitability of the soil and locality for our various species is most easily recognised when they are growing together; and it is only then that the forester can at once know for certain what species to grow or favour in any given soil or locality.—This advantage comes out most conspicuously in a

new country like India, where so little is yet known of the habits and requirements of even our principal species, and this especially so when sowings or plantations on a large scale are to be made. Mistakes committed in executing the various forest operations can be detected much more easily in mixed than in pure crops, and generally, if not always, early enough to prevent any serious or further damage.

VIII. Mixing species in a forest economises labour and time, and facilitates work and supervision.—Given a certain definite area of forest and certain species to be grown there. If these species are raised pure, they will of course occupy as many distinct sections of the area; and, if an annual supply of the *wood of each species is required, a portion of each section* will have to be worked every year, thus creating so many independent centres of work. But if all these species were intermixed, the same result would be obtained by working at only a single point every year, and the whole area would be divided into a regular succession of coupes of convenient extent, instead of innumerable small patches very difficult to look after and work, because those taken in hand in any given year are necessarily scattered here and there all over the forest without any definite order.

IX. A mixture of species contributes in various ways towards equalising the length of the rotation required by our various species.—A species that protects the soil very imperfectly after a certain comparatively early age has been reached, must allow it to deteriorate, unless it is cut soon after. The soil, deteriorating on account of the imperfect leaf-canopy, reacts on the species, and weakens and arrests its growth, and this induces premature decay. A soil improving species, on the other hand, will never fail to attain the finest growth of which it is capable on any given soil, which it will gradually render more and more suitable for itself. Now mix both species together, and thanks to the improvement of the soil effected by the second, and to the denser leaf-canopy and the maintenance of favorable influences due to the mixed growth, the longevity of the first must necessarily be enhanced.

X. By a mixture of species a forest is generally able to yield marketable produce at an earlier age than if it consisted of pure crops.—The reason is obvious. The trees, thriving better, often acquire, in spite of the closer growth, a given size at a younger stage of growth. But, what is more to the point, as the stems in a mixed forest are more numerous, the first series of exploitations (*cleanings* and first *thinnings*) become necessary much earlier. Besides this, as in a mixed forest, owing to the different habits of the trees and their different requirements as to light, not only does a given number of stems form a denser leaf-canopy than in a pure forest, but a gap made in that

canopy is sooner filled up, so that, with no heavier stock on the ground, the first cuttings may be made earlier.

XI. When a forest is regenerated naturally, its regeneration is better assured if it is mixed.—Seeds of one species or another are sure to be produced in less or greater abundance every year all over the forest. A great number of these must germinate, and, wherever sufficient light reaches the ground and other conditions are favorable, a large proportion of the seedlings thus produced must establish themselves. Moreover, as the seeds of *different species germinate with different* degrees of facility and require different degrees of heat and soaking, it is certain that, whatever the character of the season of vegetation, some seedlings cannot fail to be produced every year. Thus in mixed forests regeneration is continually going on with more or less vigour; and when the natural conditions for the development of an abundant seed-crop and the germination and establishment of the young seedlings are favoured by the forester by means of certain special operations, the chances of failure are singularly lessened.

XII. Mixed forests, as a rule, yield a larger revenue than pure forests, provided of course that the component species are all marketable.—This follows directly from II, III, IV, V, VI, VIII, and X.

XIII. A mixed forest adorns the country more than pure forest, and thus affects beneficially the physical, æsthetic, moral, and mental development of the people.—This advantage is not to be despised, and is by no means of slight importance in its effects on the genius of a people. The finest poetry has had its inspiration from the forests. The manliest portion of a nation is generally that which inhabits the interior or the borders of forests. The beneficial influence of forests is seen in the universally admitted necessity of people's parks, &c., in civilised communities.

§5.—*Conditions necessary for a mixture of species.*

In a general manner it may be said that the possibility of obtaining and maintaining a mixed growth depends—

1. *On the suitability of the soil for the more or less prosperous growth of more than one species.*—Many large stretches of laterite in Burmah practically exclude the existence of other species besides the eng. In the Central Provinces certain ferruginous soils can bear nothing but *Boswellia thurifera*. *Terminalia tomentosa* occupies almost by itself patches of stiff, wet soils in the immediate vicinity of sal and teak forest. And so on. It is not enough if two or more species can simply grow in a given soil; their vegetation on it should be vigorous enough to enable them to survive in the struggle for existence with little or no extraneous aid on the part of the forester.

2. *On the suitability of the climate and locality for the more or less prosperous growth of more than one species.*—This is self-evident.

3. *On the ability of the mixed species jointly to maintain and improve the fertility of the soil.*—If the mixed growth were such that the soil deteriorated under it, then the proportion of some one species, the hardiest and most vivacious of the mixture, would, in the majority of cases, gradually increase to the detriment of the rest, and in time the crop would consist wholly, or almost wholly, of that species.

4. *On the requirements of the several species as regards light.*—All woody species require light in order even to simply remain alive, but some can bear shade better than others. Generally speaking the ability of a plant to bear shade is proportionate to the shape (spread and depth) of its crown, as well as to the height of the latter above the ground. We may also say that transplants in plantations stand heavier shade than seedlings raised *in situ* in sowings, since the former, owing to the arrested development of their main roots due to the operation itself of transplanting, absolutely require a certain degree of shade to prevent a too rapid transpiration. Moreover, seedlings, whether transplants or raised *in situ*, suffer less under shade than stool-shoots or root-suckers, since growing, as they do, much less vigorously than the two latter they demand less insolation.

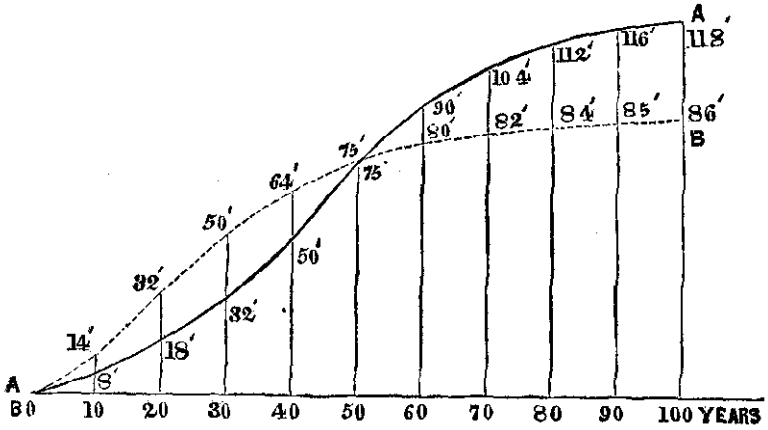
5. *On the relative hardihood of the several species.*—The hardihood of the various species during their youth is very various, and depends in a great measure on the character of the locality and soil in any given case. In certain localities, and in certain soils, some species cannot do without the protection against frost and drought afforded by shade and cover, while others, again, although able to grow up in the open, nevertheless thrive better when sheltered. And, generally speaking, all species whatsoever suffer less from shade in good soils and in a mild equable climate than anywhere else.

6. *On the relative rapidity of their growth in height at various ages, especially during their youth.*—It matters a great deal whether in a mixed crop the more shade-bearing species grow up with greater, equal, or less rapidity than the rest; and the importance of this consideration is naturally greater during their youth than at any other time. To take only a single instance, if the crop consists of individuals of more or less the same age or height, it is obvious that the more rapidly growing species, provided they are also the most shade-bearing, will, as soon as they meet their crowns over the rest, kill or at least permanently throw back these latter; while, if the crop is quite young, these must be entirely killed out wherever the former are numerous enough.

Regarding the rate of growth in height of our various

species in mixed forest, we have no trustworthy information. And, indeed, in a continent like India, we are bound to obtain very different figures for one and the same species according to the locality and the region in which it may grow in each case. When such information is forthcoming, it will be very useful to make comparative diagrams of the relative rapidity of growth of different species standing together in the same forest.

The varying rapidity of growth of each species would be delineated by a curve with its generating rectangular co-ordinates, the abscissa representing the age, and the ordinate the height of the average tree at that age. For the sake of example, I give below a comparative diagram for two trees, which I will call respectively A and B; the curves are traced by means of the respective heights attained at 10, 20, 30, 40—100 years of age.



The above diagram shows at a glance that up to the age of 74 years B grows faster than A; at 75 it is overtaken by the latter, which then gets away from it. The rapidity of growth of A is slow for the first ten years, then becomes rapid up to seventy years, after which it decreases gradually, and becomes almost stationary. B, on the other hand, grows up rapidly at once, until it reaches the age of seventy-five years, and then makes little head afterwards. In the diagram $\frac{1}{30}$ inch on the axis of X, or horizontal line, represents one year, and similarly $\frac{1}{60}$ inch on the axis of Y, or, which comes to the same thing, on the perendicular lines, represents one foot.

7. *On the quantity and spread of the roots of the several species.*—This circumstance always possesses a certain degree of importance. Some species develop a larger mass of roots and rootlets than others. One species will throw out its main roots horizontally, while those of another will, for the most part, run through

the ground obliquely, and sometimes (as in the well-known cases of sal and jand) even vertically, being thus able to draw nourishment from the deeper layers of the soil. The roots and rootlets of some species are invasive, while those of others, especially while in the seedling stage, wither away in too close contact with the same organs of another species, with which they may be growing.

8. *In the majority of instances, on the presence of different-aged individuals.*—This point has been explained in sufficient detail under the head of "General Remarks" in Sections III and IV of the present Chapter.

§6.—*General rules for growing mixed crops.*

We may now lay down the following general rules to be observed in growing mixed crops :—

I. The predominant species, whether there be several or only one, ought to be soil-improvers. This rule requires no explanation.

II. Shade-bearing species may be intermixed, if they possess the same rate of growth in height, or if the slower growers can be protected against the more rapid growers either—

(*a.*) By artificial cultivation a certain number of years in advance of the latter.

(*b.*) By being able to produce naturally an advance growth under the old standing crop, while the more rapid growers can be reproduced naturally only by means of actual regeneration fellings, thus gaining a sufficient start on these latter.

(*c.*) By cultivation, whether artificial or natural, in sufficiently predominant numbers.

(*d.*) By pruning and lopping off overhanging branches of taller growth of other species, or keeping it down by topping or cutting it back wherever and whenever necessary.

III. Shade-bearing (in other words, dense-crowned) species may be intermixed with shade-avoiding (in other words spare-crowned) species, when these latter grow more rapidly or are given a sufficient start ahead of the other. This start must, of course, be sufficient to prevent their being ever outstripped and thus overtopped.

IV. Shade-avoiding species ought not to be intermixed by themselves in any permanent manner, since in crops so composed the soil is not only bound to degenerate (violation of Rule I), but the slower growers must inevitably be suppressed by the rest.

Exceptions to this Rule :

(*a.*) *On a fertile soil, which a spare or interrupted leaf-canopy cannot hurt, a mixed growth may consist of shade-avoiding species only.*

(β.) *On very poor soils, such as those on which the Boswellia thurifera, &c., thrive, other shade-avoiding species, provided they are sufficiently valuable, such as teak, &c., may be mixed with the former. This mixture is often not only justifiable but also necessary. For instance, in many forests consisting chiefly of Boswellia, the teak has no other nurse to protect it against frosts.*

V. Individuals of species, which do not form the prevailing tree in a forest, ought to stand scattered singly, or in small bouquets, and not in large groups, in the midst of the remaining growth. If those species have dense crowns, such groups would hurt with their heavy shade trees of other species standing round them, without helping them to any appreciable extent in clearing their boles; while if they possess spare crowns, the soil below them would necessarily deteriorate. Besides this, unless the species forming the surrounding growth possessed the same requirements as to light as the trees composing the groups, the stems standing along the edge of those groups would grow unequally, putting on more wood on one side than on another, and would thus be ill-adapted for boards and scantlings of the better descriptions, which would obviously contract and expand in the most irregular manner, and thus be subject to warp very considerably.

Moreover, as has been already shown above (§4, advantage XI) a mixture of several species facilitates the natural regeneration of a forest, so that the existence of pure groups here and there throughout the forest increases the difficulty of its natural regeneration.

Exceptions to this Rule :—

(α) *When the fertility of the soil varies so that we have well-defined patches of distinctly different degrees of fertility, there is no alternative but to allow each patch to be stocked with the species, be it one or several, best suited to it.*

(β) *When a shade-avoiding species has to be cultivated side by side with a more rapidly growing and particularly dense-crowned species, there is similarly no alternative.*

(γ) *Certain individuals of a crop are sometimes preserved, when the rest of the crop is felled, in order to allow them to acquire larger dimensions. These must inevitably inflict some injury, by the cover of their crowns, on the succeeding new generation. But the mischief can evidently be minimised by selecting them standing in groups of greater or less extent.*

§7.—*Characteristics of an auxiliary species.*

The meaning of the expression "auxiliary species" has been clearly explained in Chapter I on DEFINITIONS. But after what has been considered in the foregoing sections, we are

now in a position to lay down more strictly the full connotation of that term.

An auxiliary species must fulfil the following essential conditions :—

1. *It must become readily marketable as soon as it has reached the pole stage.*—Until this stage of growth has been attained, every individual tree and shrub in a crop, by its struggle for existence with its neighbours, contributes towards the favorable development of that crop. After this period a tree here, and a tree there, hampers the free growth of, or threatens to suppress, others more valuable than itself, and must, therefore, be removed at once. Unless the stems thus cut are collectively readily marketable, and their sale-value is at least sufficient to cover cost of felling and removal, it is evident that the unproductive nature of this operation would, in the majority of instances, prohibit its ever being undertaken at the right moment.

2. *It must be a soil-improver.*—This condition is obvious, if the other species in the crop are shade-avoiding, and, therefore, spare-crowned ; and it is equally obvious that, if these latter species are shade-bearing and hence dense-crowned, their auxiliary must also be dense-crowned, and thus necessarily a soil-improver.

3. *As a consequence of the immediately preceding condition, it must also be shade-bearing.*—To be dense-crowned is to be shade-bearing.

4. *It must be able to thrive in the same soil as the principal species.*—This is a truism.

5. *It must possess a different ramification of branches and roots from that of the principal species.*—In other words, it ought to be able at once to occupy or fill up space in the soil and in the leaf-canopy, which the principal species cannot profitably utilise ; and it must be able to do this without tending to invade and strangle the crowns and root-apparatus of the latter.

6. *Its stature must not be less than the minimum length of bole demanded from the principal species.*—In no other way, save very exceptionally, could this length of bole be produced, and the leaf-canopy, at the same time, maintained in a complete state.

7. *If natural regeneration is sought, the auxiliary species should be able to reproduce itself spontaneously and readily by seed from a few seed-bearers only ; and if the regeneration is to be effected artificially, its propagation by means of sowing or planting, or both, ought to be easy and inexpensive.*—It stands to reason that as a crop ages, the relative proportion of the principal species ought to increase as much as practicable. Hence we must be able to effect the natural regeneration of the auxiliary species with as few seed-bearers as possible.

8. *Its longevity ought to be at least equal to the term required for the trees of the principal species to attain their full length of bole.*—Otherwise, after the death of the trees of the auxiliary species, none could be produced for years to take their place, and in the meantime the absence of companions to help in drawing them up and in pruning their boles naturally would affect detrimentally the longitudinal growth of the trees of the principal species.

The preceding is a complete enumeration of the *essential* characteristics of an auxiliary species; it remains now briefly to mention the *useful* and *desirable*, but not essential, characters of the same. They are—

1. *Rate of upward growth, until the high pole stage is reached, somewhat slower than that of the principal species.*—In other words, it is desirable that at no stage of growth should the auxiliary be able to rise up on a level with, much less to overtop, the principal species.

2. *A hardy constitution.*—Young individuals of the auxiliary species should be able to stand a certain appreciable degree of exposure.

3. *Longevity not inferior to the rotation applicable to the principal species.*—This is the best guarantee for successful natural reproduction of the auxiliary species, for the presence of a sufficient number of seed-bearing individuals of it, when the crop comes under regeneration just before being felled, is thereby assured.

4. *Ability to shoot up again readily after repeated cutting back or topping off.*—Many an individual of the principal species must be saved from suppression by faster growing individuals of the auxiliary class, and this can be done only by keeping these latter down for a time by cutting them back or topping them, as the case may require, once or more frequently.

5. *Persistence of foliage during as many months of the year as possible, combined, of course, with a lower stature (Essential Condition 6), and slower rate of upward growth (Useful and Desirable Character 1).*—This will add to the effectiveness of the auxiliary species as a soil-improver, and as a nurse for any advance growth that may come up.

6. *Accommodating nature as regards soil and situation.*—The possession of this quality must materially facilitate the culture of the auxiliary species in the general interests of the entire crop.

SECTION VII.—*Causes of deterioration of a forest.*

I may most appropriately close the present Chapter on the *Struggle for Existence* by summarily detailing the causes which lead to the deterioration of a forest. These causes may be collected under four main heads: (*A*) the degeneration of the

soil; (*B*) unfavorable modification of climatic conditions; (*C*) faulty operations; and (*D*) defective protection.

A.—Degeneration of the soil from—

(*a*). All the component species being shade-avoiding, and hence contracting and thinning their crowns at too early an age.
(*b*). Incompleteness of the leaf-canopy, even when soil-improving species are on the ground.
(*c*). Excessive removal of layer of dead leaves as they fall.
(*d*). Fires.
(*e*). Flooding, with either (i) infiltration and deposit of injurious saline substances, or (ii) the soil rendered marshy for a less or more protracted period owing to deficient drainage.
(*f*). Excessive hardening and caking of the surface by the tread of cattle.
(*g*). Formation of landslips, including the washing away and erosion of the surface soil by rain.
(*h*). Formation of a too acid humus.

B.—Unfavorable modification of climatic conditions due to, or manifested by,—

(*a*). The clearing of adjoining forests.
(*b*). Severer, or more frequent, untimely frosts.
(*c*). Diminished and irregular rainfall.
(*d*). More frequent and violent storms.
(*e*). Heavier and more frequent falls of snow and protraction of the time during which it lies on the ground.
(*f*). Sensibly hotter and drier winds.
(*g*). More frequent recurrence of destructive hail storms.
(*h*). Sensible change in the average temperature of the seasons.

C.—Faulty operations, *viz.*—

(*a*). Opening out leaf-canopy too much.
(*b*). Taking out more than the actual sum of production.
(*c*). Untimely or neglected fellings.
(*d*). Felling in one place over too extended an area.
(*e*). A faulty mixture both as regards the species selected for cultivation, and their respective proportions.
(*f*). Unsuccessful regeneration.
(*g*). Faulty arrangement and succession of coupes and fellings.
(*h*). Indiscreet export operations.
(*i*). Injudicious manner of making fellings and cuttings.

D.—Defective protection against—

(*a*). Fire.
(*b*). Cattle.

(*c*). Ravages of game and insects.
(*d*). Promiscuous cutting and lopping for fodder, manure, &c., including the exercise of injurious rights.
(*e*). Destructive floods, and erosion and landslips.
(*f*). Offenders.
(*g*). Multiplication of destructive fungi and other parasites, and undesirable epiphytes.
(*h*). Destructive climbers.

CHAPTER III.—*Classification of Indian Forests.*

In the preceding Chapter the conditions which regulate the natural struggle for existence between the individual plants of a forest crop were studied with special reference to India. As those conditions necessarily vary from region to region, from locality to locality, our forests also vary in a corresponding degree with regard to the component species and their relative proportions. All these different classes of forest may, however, be reduced to a few broad well-defined types founded on permanent and clearly-marked characters. The following scheme is an imperfect attempt to exhibit this classification as far as the very incomplete materials at my command permits me to do.

I.—EVERGREEN FORESTS—
- (1) Littoral forests.
- (2) Swamp forests.
- (3) Babul forests.
- (4) Tamarisk forests.
- (5) Tropical evergreen forests.
- (6) *Pinus Merkusii* forest.
- (7) Temperate forests—
  - (i) *Castanopsis* and *Engelhardtia* forests of Sikkim.
  - (ii) Oak and magnolia forests of Sikkim.
  - (iii) Oak and magnolia forests of Burmah and Assam.
  - (iv) *Pinus Khasya* forests of Burmah and Assam.
  - (v) *Pinus longifolia* forests of the Western Himalayas.
  - (vi) Temperate oak and rhododendron forests of the Western Himalayas.
  - (vii) Himalayan box forests.
  - (viii) Cypress forests of the Western Himalayas.
  - (ix) Forests of deodar and its allies.
  - (x) *Pinus excelsa* forests of the Western Himalayas.
  - (xi) The Nilgiri forests.
- (8) Alpine evergreen forests—
  - (i) Rhododendron forests of the Eastern Himalayas.

(ii) Alpine conifer forests of the Eastern Himalayas.
(iii) Silver fir forests of the Western Himalayas.
(iv) Juniper forests.
(9) Sandalwood forests.

II.—Deciduous Forests—

(1) Forests of cold weather leaf-shedders—
(i) Sissoo forests.
(ii) *Boswellia thurifera* forests of Central India, including Berar and the Deccan to within 20 miles of the Western Ghats.
(iii) Alpine birch forests.
(2) Forests of hot weather leaf-shedders—
(i) *Quercus semecarpifolia* forests of the Western Himalayas.
(ii) Sal forest.
(iii) Mixed forests in which teak is present.
(iv) Mixed forests without teak.
(v) Eng forest—
(*a*) *True Eng forest.*
(*b*) *Hill Eng forest.*
(vi) Khair forest.
(vii) *Hardwickia binata* forest.
(viii) Bamboo forest.
(ix) *Anogeissus pendula* forests of Rajputana and Bundelkhand.
(x) *Melanorrhœa usitata* forest.

The first great division into evergreen and deciduous forests is founded on the persistence of the foliage, according as the majority of the component species are evergreen or deciduous. The subdivisions of the first class are based on differences of climate, soil and locality; of the second class on the season of leaf-fall. The seventh subclass of evergreen forests will be examined under seven types, the first and second subclasses of deciduous forests under three and seven types respectively. These types are by no means exhaustive of their corresponding subclasses, but they seem to me to represent the more important forms of these latter according to my present imperfect knowledge and experience, and I may be allowed to retain them provisionally until more extended acquaintance with our forests, and information kindly supplied by others, enable me to draw up a more complete analysis, in which subtypes would with advantage be admitted.*

* I would earnestly invite readers of these Notes in other parts of India, especially the Madras and Bombay Presidencies, Mysore, Coorg, Lower Bengal, Assam and Burmah, to correct, through the medium of the "Indian Forester," the numerous errors of omission and commission, which it was impossible not to make in attempting, with my necessarily limited experience and materials, to reduce to distinct types the countless forms of forest growth in India. Had I not felt confidence

In the following Sections I have endeavoured to be as brief and summary as possible; lengthy and detailed descriptions will find their place in Book III.

SECTION I.—EVERGREEN FORESTS.

1. LITTORAL FORESTS.—These are low-lying forests growing on silty alluvial land bordering the sea, and ascending the larger rivers as far as the tidal wave. They are found along the coast and tidal creeks and lagoons of the Peninsula, of Bengal and of Burmah, and skirting the estuaries of the Indus. Salt water is a necessary condition of existence for these forests, and types and subtypes are produced according to the degree of saltness of the water, which degree varies with the quantity of fresh water brought down by rivers or falling as rain. Along the sea itself, and often far extending into it, are found the true mangrove forests consisting of species of *Rhizophora, Bruguiera and Geriops*, &c. The ground is muddy in the extreme and more or less destitute of low vegetation. But as we ascend the streams and estuaries, where the ground is covered only during spring-tides, the undergrowth becomes denser and consists of coarse sedges and seedlings of the larger trees, while the true mangroves gradually give place to species of *Avicennia, Sonneratia*, and *Heritiera*, which form the prevailing trees, and *Phœnix paludosa* occurs. In the Gangetic delta the higher land bears in many cases almost pure forests of the well-known *Heritiera littoralis (Sundri*, whence probably the name SUNDARBANS for all the forests of that delta).

In this subclass may be included forests of *Casuarina equisetifolia* and of other trees growing on the salt sea sands, and also of cocoanut growing on saline calcareous sand along the seashore.

A remarkable fact to note in connection with Littoral Forests is the occurrence there of certain species, like *Pongamia glabra, Cordia Myxa, Tamarix indica*, &c., which are also found indigenous inland many hundred miles from the sea and out of brackish soil.

Do fires by any chance ever occur in any of these forests? And if so, under what circumtasnces and with what severity?

2. SWAMP FORESTS.—This class of forest occurs on land subject during the rains to freshwater inundations, sometimes to a depth of 6 feet, and where the surface of the ground remains more or less muddy throughout the year. Bamboos are generally absent; herbage, with the exception of sedges, is

in receiving the help I solicit, I should not, I need hardly say, have prematurely published these Notes, which are more in the way of first suggestions how to treat the subject of the present Chapter, than a formal, although imperfect, description of the various classes of Indian forests. I venture to cherish the hope that *corrections and additions* will pour in and flood me with an *embarras de richesses*.

scanty; and orchids and ferns cover the trunks and branches of the trees. The characteristic species in such forests in Burmah are chiefly *Anogeissus acuminata* (*deciduous*), *Mangifera, Elæocarpus, Garcinia succifolia, Barringtonia acutangula*, &c. In Eastern Bengal and Assam they are *Dillenia indica* and *Lagerstræmia Flos-Reginæ*, the latter being, however, a deciduous tree. In Oudh and the North-West Provinces the principal species are *Barringtonia acutangula, Albizzia Lebbek, A. procera, A. stipulata, Trewia nudifora, Randia uliginosa*, &c., all, however, deciduous trees. I may also mention Eugenias, Willows, Canebrakes and the *Putranjiva Roxburghii* as generally characteristic of Swamp Forests.

3. BABUL FOREST.—The babul (*Acacia arabica*) forms large masses of pure forest in Lower and Middle Sindh, where it covers upwards of 27,000 acres, and in the Northern Deccan and in Guzerat, and, to a small extent, in the Umballa district of the Panjab. This tree produces every year an abundant crop of seed, which germinates freely, especially where, as in Sindh during the floods of the Indus, it finds enough moisture to get thoroughly soaked. In the Northern Deccan and in Guzerat, where the tree grows chiefly on strong loamy soils, the germination and spread of the seed is facilitated by its passing through goats, who greedily devour it and thus favour the Babul at the expense of any other species which may come up at the same time, but which cannot survive their fatal bite. Mr. Drysdale says that in the Berars the *babul bans* are dense enough to prevent any undergrowth, grass included, from coming up, and that fires do not consequently occur.

What is the nature of the undergrowth, including grass, and of what frequency and severity are conflagrations in these forests in other parts of India?

4. TAMARISK FOREST.—Extensive forests of this subclass occur on the low, moist, alluvial lands, which are often impregnated with salt, along the Indus and its tributaries. The frequent new formations of such land along the banks of the shifting rivers get covered early in spring, on the subsidence of the floods, with a dense mass of tamarisk seedlings, mixed more or less with young plants of *Populus euphratica* and *Acacia arabica*, under trees of which species the tamarisk forms a close undergrowth.

Is there any herbage in these forests, and do fires ever occur?

5. TROPICAL EVERGREEN FORESTS.—This subclass of Evergreen Forest is confined to the Moist Zone, where the rainfall is 70 inches and upwards. Large areas of it occur in the plains and hills of Burmah and Assam, in Sikkim and South-Eastern Bengal, and in the Western Ghats. It is known as Lower Hill Forest in Bengal and Assam. It occurs in shady valleys, on the slopes of hills up to 3,000 feet, along watercourses,

and wherever an abundant perennial supply of moisture in the soil is available. The growth is exceedingly dense, and the variety of species is very great, comprising trees of all dimensions, *which sometimes form a mass of foliage 200 feet thick.* The lofty trees which tower above the rest are frequently deciduous. Among them may be noted *Artocarpus Chaplasha, A. Lakoocha, Albizzia Lebbek, A. stipulata, Schima Wallichii, Pterocarpus indicus,* species of *Dipterocarpus* and *Sterculia, Xylia dolabriformis,* &c. To these may be added numerous species of *Ficus,* including the Caoutchouc tree, which develops a larger crown and attains a greater girth and height than any other tree in the moist forests of Assam. There are also oaks, *Castanoposis,* laurels, species of *Meliaceæ,* (the most noteworthy of which is the toon), *Mesua ferrea, which* predominates over large areas in Assam, &c. Bamboos of various species often form a conspicuous heavy undergrowth; gigantic creepers intertwine amongst the trees; palms, screw pines, *Scitamineæ* and ferns are abundant; but grassy herbage is rare. As regards shrubby vegetation, it is densest along open watercourses, in cleared spots, and along the outskirts of the forest, and often disappears entirely in dark places in the interior. In Bengal, in spite of the dense growth and evergreen nature of this subclass of forests, fires are annual, unless specially kept out, and do much damage. In Assam, on the other hand, it is believed that fires are unknown. (Is this true?) In Oudh and the North-West Provinces there is, perhaps, a fire in only one year out of ten, and this always late in the hot season, since the total combustible matter consists of the dry leaves, which accumulate on the ground only after the grass outside the forest has already been burnt up to its very edge, and which can, therefore, take fire only by the act of an incendiary. In Burmah fires rarely occur. As there is combustible matter in these forests during only a very short period of the year, and the quantity of it is inconsiderable, and as the leaf-canopy is constant throughout the year, it follows that conflagrations, when they do occur, do comparatively slight damage, and can be easily controlled.

More information, especially as regards Southern India (including the Bombay Presidency) is required and will be very thankfully received. It will, perhaps, be necessary to establish types in order to do justice to the vast and varied areas which these forests cover. For instance, it seems to me desirable to treat of "Mesua ferrea Forest" as one type.

6. PINUS MERKUSII FOREST.—This pine forms forests on the sandstone hills of Upper Tenasserim at altitudes varying between 1,500 and 2,500 feet, and also occurs as solitary trees down to as low a level as 500 feet above the sea.

What is the nature of the undergrowth, grass included, and what is the nature, prevalence, and severity of forest fires?

7. TEMPERATE FORESTS.—These are all hill forests and extend vertically from an altitude of about 3,000 feet up to about 8,000 feet, ascending, however, in some cases, as in the deodar type, much higher. The prevailing species are either evergreen broad-leaved trees with a few deciduous ones, of which *Quercus semecarpifolia*, *Engelhardtias*, maples, walnut, *Andromeda*, and *Alnus nepalensis* are among the chief, or conifers either pure or mixed with broad-leaved trees. Where broad-leaved trees prevail, various kinds of oak, *Castanopsis*, magnolias and laurels, *Bucklandia populnea*, *Rhododendron arboreum*, &c., are the principal trees, associated with *Andromeda ovalifolia*, *Arundinaria*, maples, species of *Cornaceæ*, *Celastrineæ*, &c. The box occurs locally over limited areas, and the yew (*Taxus baccata*) is sometimes met with. The trees are frequently covered with epiphytic ferns and mosses, and *Loranthaceæ* are common. The types of this subclass are very numerous, but for the present, until more information is collected, the following eleven may be noted:—(i) *Castanopsis* and *Engelhardtia* forests of Sikkim; (ii) Oak and Magnolia forests of Sikkim; (iii) Oak and Magnolia forests of Burmah and Assam; (iv) *Pinus Khasya* forests of Burmah and Assam; (v) Forests of *Pinus longifolia* of the Western Himalayas; (vi) Temperate Oak and Rhododendron forests of the Western Himalayas; (vii) Box forests; (viii) Cypress forests of the Western Himalayas; (ix) Forests of deodar and its allies; (x) *Pinus excelsa* forests of the Western Himalayas; (xi) The Nilgiri forests.

(i). *Castanopsis and Engelhardtia Forests of Sikkim.*—This type is met with between 3,000 and 6,000 feet of altitude. The chief and most numerous trees are species of *Castanopsis*, *Engelhardtia spicata*, *Prunus Puddum*, *Alnus nepalensis*, *Juglans regia*, *Bucklandia populnea*, maples, birch, &c., with a few oaks at the higher elevations. Toon grows scattered throughout these forests, and attains a huge size, some trees yielding logs measuring 500 cubic feet. The undergrowth is especially dense in the more open portions, and consists of *Artemisia*, *Rubus flavus*, *Mæsa indica*, *Sarauja*, *Eurya*, &c. Tree ferns are common, and the hill cane (*Plectocomia himalayana*) forms dense thickets.

What is the degree of prevalence and destructiveness of fires in these forests?

(ii) *Oak and Magnolia Forests of Sikkim.*—These forests begin at an elevation of about 6,000 feet, and are composed of a dense tall growth of oaks and magnolias, mixed with *Castanopsis rufescens*, *Machilus odoratissima*, *Phœbe lanceolata*, an *Actinodaphne*, *Echinocarpus dasycarpus*, *Acer Campbellii*, *Rhododendron arboreum*, *R. argenteum*, *Andromeda ovalifolia*, *&c.*, *&c.* The oaks are *Quercus lamellosa*, by far the commonest, *Q. annulata*, *Q. spicata*, *Q. acuminata*, *Q. pachy-*

phylla and *Q. fenestrata.* Of the magnolias the principal are *Magnolia Campbellii* and *Michelia excelsa, lanuginosa,* and *Cathcartii.* The undergrowth is dense and consists of *Strobilanthes,* ferns, &c., and, on the higher slopes, of the *Mayling* bamboo (*Arundinaria racemosa*), which occurs gregariously in dense thickets preventing the growth of other vegetation.

Is herbage abundant? Do fires ever occur? If so, are they destructive?

(iii). *Oak and Magnolia Forests of Burmah and Assam.*—The following is a description of the Burmese subtype condensed from KURZ'S "Forest Flora of British Burma":—These forests begin at about 3,000 feet and reach the topmost limit of tree vegetation in Burmah. The atmosphere is characterised by great dampness. The species are very numerous; the principal are several species of oak (*Quercus fenestrata, spicata, Brandisiana, semiserrata,* &c.); of *Castanopsis* (*C. indica, tribuloides, Falconeri, diversifolia, &c.*; of magnolias (*Ilicium,* &c.); and of rhododendron (*R. arboreum, formosum* and *moulmeinense), Ternstræmia japonica, Eugenias, Myrica sapida, Vaccinia, Bucklandia populnea, Symplocos, Andromeda ovalifolia, Cornus oblonga,* laurels, *Dillenia aurea, &c., &c.* Among these grows a fan palm (*Chamærops khasyana*) and a climbing *Plectocomia.* The undergrowth is very dense, especially when light has free access, and consists of bracken, *Rubus,* Gentians, Sundews, *Senecio, Lobelia, Galium,* &c. *Arundinaria elegans* forms a very dense undergrowth in places, and the trees are covered with epiphytic ferns and orchids, *Cyrtandraceæ,* &c., interwoven with mosses and lichens.

Information required regarding the prevalence and severity of forest fires.

(iv). *Pinus Khasya Forests of Burmah and Assam.*—These forests are found in Burmah above an elevation of 3,000 feet, and in Assam between 2,000 and 6,000 feet. In Burmah this pine grows pure or very nearly pure, except in deep gullies and valleys, where it is mixed with a large proportion of broad-leaved species, or is sometimes entirely absent. The pine generally towers above the other trees, often attaining a height of 200 feet, whence its gregarious character.

What are the broad-leaved species mixed with this pine in Burmah? What is the nature of the undergrowth, shrubby as well as herbaceous? What is the frequency and severity of forest fires? For Assam information on every point is wanting.

(v). *Forests of Pinus longifolia.*—This type of Evergreen Forest is extensively represented throughout the Himalayas from the Indus to Bhutan. It enters the Moist Zone, but only in patches, and continuous stretches of it are found chiefly or solely in the Intermediate Zone. It is confined to warm dry slopes and to free soils that are mainly silicious. It is, generally speaking, limited between 4,000 and 6,000 feet of

altitude. The pine is usually all but pure, but *Quercus incana* frequently forms, over limited areas, from 5 to 10 per cent of the crop, exclusive of course of the deeper ravines and any moist slopes where the pine disappears. The Valuation Survey of 17,000 acres, including the dampest localities, round Ranikhet gives an absolute proportion of seven of pine to two of oak. These forests are generally very open, as the pines never, except in their youth, join crowns. The undergrowth consists of barberry, *Gratægus Pyracantha*, holly, wild pear, laurels, species of *Celastrineæ*, *Caprifoliaceæ*, *Cornaceæ*, and straggling growth, such as roses, brambles, &c. The grass is usually spare and short, never rising above three feet. Forest fires are an annual occurrence, and are very severe owing to the thick layer of needles that covers the ground; but the flames very rarely rise high enough to scorch the foliage of trees above the middle size. Usually the fire burns off the leaves only of saplings, its progress is comparatively slow, and the only sign by which a recently burnt forest can be recognised at a distance is the blackened soil. It is a remarkable fact that *Pinus longifolia* at Naini Tal is unquestionably a deciduous tree.

(vi). *Temperate Oak and Rhododendron Forests of the Western Himalayas.*—This type of Temperate Forest occurs in more or less large patches or belts generally interspersed between stretches of forests of *Pinus longifolia*, of cypress, of box, of deodar and its allies, and of *Pinus excelsa*, beginning at 4,000 feet and going up to 8,000 and sometimes 8,500 feet. Moisture is essential to its existence. It thus occupies chiefly northerly and north-westerly slopes and all ravines and deep gullies, and also takes possession of the higher southerly, easterly and westerly slopes in the Moist Zone of the outer Western Himalayas. The oaks and rhododendrons are mixed with numerous other trees, chiefly broad-leaved, of which *Andromeda ovalifolia*, *Machilus odoratissima*, mulberry, ash, *Viburnums*, species of *Cornus*, *Rhamnus* and *Euonymus*, birches, alders, willows, hollies, honeysuckles, hornbeams, Maples, *Rhus*, *Pyrus variolosa* and *Symplocos cratægoides* are the principal. The species of oak that grow in these forests are, beginning with the lowest, *Quercus annulata* ascending up to 5,000 feet, *Quercus incana* between 3,000 and 8,000 feet, *Quercus Ilex* above 6,500 feet, *Quercus dilatata* above 4,500 feet, *Quercus semecarpifolia* above 6,500 feet, and *Quercus lanuginosa* in a few isolated patches between 7,000 and 8,000 feet. All these oaks are more or less gregarious, notably so *Quercus semecarpifolia** and *Quercus incana*. The growth, wherever it has been unmolested, is extremely dense, with a close undergrowth of small shrubs such as *Daphnes*,

* *Quercus semecarpifolia* forest is described as a separate type under Deciduous Forests.

Cotoneasters, roses, brambles and species of *Saxifrageæ*. *Arundinarias* are also very common, and in open places *Indigoferas* and *Desmodium* form impenetrable thickets. Although this type of forest has been classed as evergreen, still most of the companion species are deciduous, as also *Quercus semecarpifolia* itself. Three palms occur in these forests—at lower elevations, *Wallichia densiflora* and *Chamærops Ritchieana*, both low shrubs, and the former forming frequently a dense undergrowth; between 5,000 and 8,000 feet, in dense forest, and in large numbers, the tall and graceful *Chamærops martiana*.

Owing to the moist nature of the localities occupied by these forests, and the closeness of the growth, fires are a rare occurrence, do comparatively little damage, and are easily extinguished.

(*vii*). *Box Forests.*—These are mixed forests occurring in small scattered patches in the Suleiman and Salt Ranges, and in the Western Himalayas between 4,000 and 8,000 feet, and in Bhutan from about 6,000 to 7,000 feet. They hardly deserve being raised into a distinct type but for the extremely valuable nature of the wood of the Box. The Box is gregarious.

Messrs. Bagshawe, Moir, Smythies and Hearle, and other gentlemen who are familiar with forests of Box, are invited kindly to publish their experiences.

(*viii*). *Cypress Forests of the Western Himalayas.*—This type of forest occurs over limited areas, between 5,500 and 8,500 feet, in various portions of the outer Himalayan ranges from Chamba to Nepal, on or in the vicinity of limestone rocks, and generally, but not always, on very steep, dry, warm rocky, slopes. The cypress is, of course, the predominant tree, associated, according to the locality, with deodar, the Himalayan spruce and silver firs, and oaks, or with oaks alone. These oaks are *Quercus incana, dilatata*, and *semecarpifolia*, and, where they find favorable conditions, they fill up the intervals between the slender and loftier crowns of the conifers, and thus help to form a very complete leaf-canopy. The undergrowth consists of barberries, *Rhododendron arboreum*, species of *Caprifoliaceæ*, *Saxifrageæ*, *Euonymus*, *Cornus*, *Ilex*, laurels, *Symplocos*, *Cratægus*, willows, &c., and undershrubs such as *Rubus spp.*, *Daphne papyracea*, *Indigofera*, *Spiræa*, &c. Herbaceous species, *Rumex*, *Potentilla*, ferns, &c., cover the soil. Owing to the generally damp and cold climate, and the absence of any considerable quantity of combustible matter, fires are rare, and do little damage.

(*ix*). *Forests of Deodar and its Allies.*—This type of Temperate Evergreen Forest is found in India in the Western Himalayas between 66° and 81° East Longitude, from a point

about 40 miles east of the Niti Pass* westwards to the boundary of Afghanistan. Generally speaking, it begins at 4,000 feet, and ascends up to 10,000 feet, and is mainly represented in the basin of the chief tributaries of the Indus, on the Tons, Jumna and Bhagirathi rivers, and on three or four feeders of the Alaknanda and Kali Ganga. As regards rainfall it extends from the edge of the moist to the vicinity of the arid zone. In the forests of this type the deodar alone covers large areas, or is associated with *Pinus excelsa* and *Abies Smithiana*, less commonly with *Abies Webbiana*, and the three oaks, *Quercus incana*, *dilatata* and *semecarpifolia*. The cypress, birch, yew, and, in Kunawar and Pangi, *Pinus Gerardiana*, are also companions of the deodar. The true deodar forests occupy the middle ground between warm well-lit southern slopes on which the *Pinus excelsa* grows almost pure, and cold moist northerly slopes where the *Abies Smithiana* forms the predominating tree. Other trees are maples, alder, *Celtis*, ash, walnut, mulberry, *Pistacia*, poplars, elms, &c. The undergrowth consists of hollies, barberries, species of *Cornus*, *Rhamnus*, and *Lonicera*, roses, brambles, *Viburnums*, willows, *Arundinarias*, *Desmodium*, *Indigoferas*, yew, hazel, &c.

What is the frequency and severity of forest fires?

(*x*). *Pinus excelsa Forests of the Western Himalayas.*—These forests begin on the edge of the moist zone and extend inwards, through the intermediate belt, into the arid zone. Although the *Pinus excelsa* itself is found as low down as 5,000 feet, and as high as 12,500 feet, still the type of forest here referred to ranges only between 6,000 and 10,000 feet. Unlike its long-leaved congener, this pine does not form pure forests of large extent, but is generally mixed, according to the elevation in any particular case, with *Pinus longifolia*, deodar, the silver and spruce firs, and *Betula Bhojpattra*. The growth is generally lofty, surmounting an under-story of the same shrubs and small trees as occur in deodar forest. Owing to the drier and more open nature of *Pinus excelsa* forest, fires are more general and destructive than in the last described type.

(*xi*). *The Nilgiri Forests.—Information wanting as to nature of growth (including undergrowth), as to whether they comprise more than a single well-defined type, and as to the prevalence and severity of fires.*

8. ALPINE EVERGREEN FORESTS.—This subclass of forests may, in a general manner, be said to begin at about 8,000 feet, and to extend to the upper limit of tree vegetation; but, as has already been noticed in the description of the types of the preceding subclass, no hard and fast line can be drawn between the two. The deodar and *Pinus excelsa* types run

* The eastern limit of deodar here given was ascertained by an exploring party I sent to Nepal last summer.

up into the zone of truly Alpine forests, and the Temperate oak type fades insensibly into the corresponding Alpine type, which is, however, deciduous (*Quercus semecarpifolia*). These Alpine Evergreen Forests are situated partly in the intermediate zone of moisture, but chiefly in the arid zone beyond. I have no personal acquaintance with these forests, and the literature in which they are described from the forester's point of view treats of them too vaguely to enable me to divide them into characteristic types. We may, however, distinguish them tentatively, and quite provisionally, into the following types :— (i) Rhododendron Forests of the Eastern Himalayas ; (ii) Alpine Conifer Forests of the Eastern Himalayas ; (iii) Silver Fir Forests of the Western Himalayas; (iv) Juniper Forests.

(i). *Rhododendron Forests of the Eastern Himalayas.*—From Mr. Gamble's description of these forests in Sikkim it would appear that the vegetation is composed chiefly of various species of rhododendron, the more common of which are *R. Campbellii, R. Falconeri, R. barbatum* and *R. arboreum.* Associated with the rhododendrons are *Betula Bhojpattra* (deciduous), several kinds of maples (also deciduous), *Andromeda ovalifolia, Hydrangea altissima,* the yew, &c. For the forester, this type possesses little importance except as local sources of supply of fuel.

Do fires ever occur ?

(ii). *Alpine Conifer Forests of the Eastern Himalayas.*—These forests consist principally of the Himalayan silver fir (*Abies Webbiana*), associated with a large proportion of *Abies dumosa* and *Juniperus recurva.*

Does Larix Griffithii occur in these forests as a companion species, or is it gregarious enough to form a distinct type of Alpine Deciduous Forest ? What is the nature of the undergrowth ? Do fires ever occur ?

(iii). *Silver Fir Forests of the Western Himalayas.*—These are extensive forests of *Abies Webbiana,* pure or mixed with maples, rhododendrons, oaks (*Quercus dilatata* and *semecarpifolia), Betula Bhojpattra, Abies Smithiana, Pinus excelsa,* &c. They sometimes ascend as high as 13,000 feet. The purest forests are found on cold northerly or westerly aspects.

Do these forests extend into the Arid Zone ? What is the composition and character of the undergrowth ? Is the leaf-canopy always very dense ? Do fires ever occur ?

(iv). *Juniper Forests.*—These forests occur at very high elevations, often forming the upper belt of tree vegetation. They range generally between 9,500 and 15,000 feet, and extend into the heart of the Arid Zone. In the Western Himalayas *Juniperus communis* and *J. recurva* form extensive patches or belts, either pure or mixed together, of low forest on dry bleak, often rocky slopes. The latter species, like the

large juniper *(J. Wallichiana)* continues eastwards to Sikkim, but ceases to be gregarious.

Is the growth dense? What is the nature of the herbage or other undergrowth?

9. SANDALWOOD FORESTS.—*Does the Sandalwood tree form a sufficiently large proportion of the forests in which it grows to permit of its being raised into a separate sub-class? If so, would Major Van Someren or Mr. Hutchins kindly favour us with descriptions of these forests, which they know so well?*

SECTION II.—DECIDUOUS FORESTS.

1. FORESTS OF COLD WEATHER LEAF-SHEDDERS.—In this subclass of forest the majority of the trees shed their leaves in the cold season or soon after the South-West Monsoon has ceased, the rest being either evergreen, such as *Abies Webbiana*, rhododendrons, junipers, yew, *Mimusops indica*, *Pongamia glabra*, &c., or, in the great majority of cases, hot weather leaf-shedders such as khair, *Anogeissus latifolia*, *Ulmus integrifolia*, &c. Three principal types of these forests may be noted, *viz.*, (*i*) Sissoo Forests in Northern India, (*ii*) *Boswellia thurifera* Forests in Central India and the Deccan up to within 20 miles of the Western Ghats, and (*iii*) Alpine Birch Forests.

(i). *Sissoo Forests.*—This type occurs mostly on silty sand or gravel along the banks and on the islands of Himalayan rivers, extending from some point a few miles above where they issue out of the hills down to from 50 to 100 miles in the plains. The sissoo is often pure or very nearly pure in it. The leaves of this tree fall in November—December. Its most frequent companion is khair, which sometimes forms as much as 10 per cent of the crop and loses its leaves soon after the end of the cold weather. Other allied species are *Ligustrum robustum*, *Albizzia stipulata*, *Julibrissin* and *Lebbek*, *Cedrela Toona*, *Bauhinia racemosa*, species of *Ficus*, *Spondias mangifera*, *Ulmus integrifolia*, *Premna mucronata*, *Bombax malabaricum*, *Zizyphus Jujuba*, &c. The growth is generally open, but is occasionally dense enough to kill out all herbage below. The undergrowth, as is to be expected in sandy soils, consists chiefly of coarse spare herbage, sometimes attaining a height of 8 feet, but more commonly not exceeding 3 feet. In consequence of this and of the generally moist nature of the sissoo localities during the greater part of the year, forest fires, although generally annual, are usually not severe.

(ii). *Boswellia thurifera Forests.*—This second type of forests of cold weather leaf-shedders is most extensively represented on the hot, dry, compact sandstone hills of Vindhyan formation along the upper and middle course of the Narbada and its tributaries, on the drier ridges and spurs of the Sathpuras, on the arid hills of the Deccan to within 20 miles of the Western Ghats, and on silicious soils in the upper basins of the

Mahanadi and Son rivers. A patch of about two square miles is also found on the southern face of the Siwaliks west of Hardwar on the Ganges. The *Boswellia* is sometimes quite pure, especially in ferruginous soils; but, as a rule, it surmounts a sparse stunted undergrowth of other species, usually hot weather leaf-shedders, such as khair, teak, *Pterocarpus Marsupium, Anogeissus latifolia, Sterculia urens,* &c., which are elsewhere large or at least middle-sized trees. In Nimar, in Central India, and in a few other places *Hardwickia binata* shares a not inconsiderable place in the leaf-canopy with it. Occasionally *Dendrocalamus strictus* and *Buchanania latifolia* are also associated with it. There is often a shrubby undergrowth of *Nyctanthes Arbortristis,* and *Symphorema involucratum.* The *Boswellia* is quite leafless by the middle of December, and does not renew its foliage until the end of June. Moreover nearly all its companions are also bare early in the hot weather. The appearance of the forests is, therefore, extremely bleak and desolate throughout the hot weather. The trees usually stand apart, and the foliage of the *Boswellia* is never dense. There is hence always a more or less heavy growth of grass, although the poverty or absence of dicotyledonous herbage is remarkable. After what has been said, it is obvious that conflagrations are an annual plague and their effects are aggravated by the dry ungrateful nature of the soil and climate, which is rendered still more dry and barren by the reaction of the fire on them. Since the *Boswellia,* under the most favourable conditions, forms only an open or interrupted leaf-canopy, we have only to keep out fire continuously in order to improve the soil and the growth and proportion of the companion species, many of which would then rise up on a level with the *Boswellia,* and ultimately form a large and valuable integral portion of the crop.

(iii). *Alpine Birch Forests.*—These forests are found in the higher ranges of the Himalayas, extending far into the Arid Zone. Their lowest limit is, in the Panjab, at 7,000 feet, in Sikkim, not under 9,500 feet. They ascend commonly to 11,000 feet, often to 12,000 feet, and sometimes, as in inner Sikkim, to 14,000 feet, and are most frequently met with on northerly and westerly aspects. The Indian Alpine Birch (*Betula Bhojpattra*) grows there almost pure, and, as it sheds its foliage in October, and does not renew it until the following April or May, these forests are leafless during half the year.

What are the allied species? What is the composition and character of the undergrowth? Do fires ever occur?

2. FORESTS OF HOT WEATHER LEAF-SHEDDERS.—In this subclass of Deciduous Forests the majority of the trees lose their leaves in the hot season. It is much more extensively distributed than the preceding one. It presents numerous types, of which, however, I will note only the following ten,

which seem to be the most important :—(i) *Quercus semecarpifolia* Forests of the Western Himalayas, (ii) Sal Forest, (iii) Mixed Forests in which teak is present, (iv) Mixed Forests without teak, (v) Eng Forest, (vi) *Acacia Catechu* Forest, (vii) *Hardwickia binata* Forest, (viii) Bamboo Forest, (ix) *Anogeissus pendula* Forests, and (x) *Malanorrhœa usitata* Forests.

(i). *Quercus semecarpifolia Forests of the Western Himalayas.*—This type of forest occurs in large patches in the Moist and Intermediate Zones, beginning at about 8,000 feet and ascending to 12,000 feet, not unfrequently forming the upper limit of arborescent vegetation. This oak is gregarious, and often forms a pure growth over considerable areas. Otherwise it is associated with a varying proportion of maples, *Rhododendron arboreum, Betula Bhojpattra* and *acuminata*, &c. The leaf-canopy is generally dense and then admits of only a light undergrowth of species of barberry, *Rhamnus, Euonymus, Lonicera, Viburnum, Ribes, Pyrus*, brambles, &c., with a herbaceous ground-covering of *Potentillas, Spiræas*, Ferns, &c., &c. Where the forest is open, *Arundinaria falcata*, and, at lower elevations, also *Indigofera heterantha* and *atropurpurea*, form a dense undergrowth. Owing to the damp climate, the all but evergreen leaf-canopy and dense covering of shrubs and herbs, fires are very exceptional occurrences.

(ii) *Sal Forest.*—In this the second type the sal is always the predominant tree, sometimes growing almost pure, otherwise associated with *Terminalias, Lagerstræmia parviflora, Dillenia pentagyna, Buchanania latifolia, Semecarpus Anacardium, Anogeissus latifolia, Bauhinias, Dendrocalamus strictus, Ougeinia dalbergioides, Eugenias, Murrayas*, laurels, species of *Ficus, Wrightias, Albizzias, Wendlandias, Pinus longifolia, Bombax*, &c.

The forests of this type form two irregular but fairly defined belts separated from one another by the Gangetic plain. The Northern or Sub-Himalayan belt extends from Assam to the Kangra Valley in the Panjab, skirting the foot of the hills and descending into the doons and valleys, and ascending in places, as near Naini Tal, to 4,400 feet. Near the western end of this belt the sal forests are less extensive, and terminate near the Beas river in a number of scattered patches of limited area. There are no sal forests in the plains west of the Ganges; while east of that river, in Rohilkhand, Oudh, Gorakhpur, and Bengal, such forests occur at a considerable distance, sometimes 100 miles, from the hills. The second, or Central Indian, belt occupies the hilly country of Behar, Rewah, Sirgooja, Chota Nagpur, Midnapur and the Maikal range of hills between the Narbada river and the open country of Raipur, extending south to the upper basins of the Indravati and Severy (both tributaries of the Godaveri) to the upper basin of the Mahanadi, and into the Northern Circars. An outlier of this belt

occurs on the sandstone hills of the Pachmarhi range, and in the valley of the Denwa. Sal forests are never found in a thriving state off free, water-transmitting soils. When they occur on stiff clays, as in many parts of Oudh, Kumaon and the Dehra Dun, the trees are generally dwarfed and seldom attain a large girth. Their range of distribution is limited and determined by the hot and dry winds of the Gangetic plain, of the Punjab, of Bundelkhand, and of the Malwa plateau, by the Central Indian trap country, and by the excessive moisture east of Tezpur in Assam.

Although this type of forest has been classed as deciduous, still the sal, which is the main tree, is in the moister localities seldom quite leafless, the new flush of leaves coming out as the old foliage is shed.

The growth is, as a rule, lofty and dense, and, with protection, is always close enough to kill out grass. Indeed the stool of the young sal is so vivacious, that even under the *régime* of annual fires it strengthens itself every year until it is able to throw up a master-shoot which, if not entirely proof against fire, is still burnt down only for a portion of its length and is ultimately able to rise up above its influence. The result of this, combined with the tendency of sal to form a complete leaf-canopy, and its affecting soils where the grass generally remains green or at least moist, and nightly dews prevail up to the middle or even the end of May, is that, with few exceptions, sal forest is to a great extent self-protected against fire. Our present forests of this type are, however, in so ruined a state that they are interspersed or surrounded with glades and blanks, in which the growth of grass is rank and high and makes partial conflagrations an annual occurrence. Such conflagrations are necessarily very severe, but the area over which they rage is becoming every year smaller as the forest encroaches on the grass land.

(iii). *Mixed Forests in which Teak is present.*—This second and extremely important type is distributed in India proper south of a line beginning at the mouth of the Narbada, running north-east below Mhow and Bhopal, thence turning north past Saugor to Jhansi, and finally from latitude 25° 30′ North sweeping round in a south-easterly direction by Jabalpur and Mandla to the Mahanadi river in Orissa; and in Burmah south of the 25th parallel of North Latitude.

In India proper there is little doubt that its northern limit from the Narbada to Jhansi and Jabalpur is determined by the low temperature of the winter months in the country outside that line, while its spread further northward elsewhere, is prevented by the greater suitability of the climate and soil for species which prevail over the teak in the struggle for existence, notably sal. It flourishes on sandstone, but it is also largely spread over more or less binding soils provided

the drainage is sufficiently free. In Burmah this type of forest ascends to 3,000 feet, in the northern portion of its range in India proper up to 3,500 feet, and in the Peninsula up to a little above 4,000 feet; but generally the growth of teak becomes stunted above 2,000 feet in Burmah and in the northern portion of its habitat in India, and about 3,000 feet in the Indian Peninsula. In Central India the growth of that species is unpromising except in a few isolated localities, as in the Ahiri Zamindari in the Chanda District, in places in Bastar, &c.

In this type of forest the proportion of teak to its associates is very variable. On alluvial soils and on the rolling trap hills of the Sathpuras, wherever extraneous circumstances, such as *Dhaya*, have driven out or kept back the other species, the teak is almost pure. Elsewhere, according to fluctuations in the nature of the soil and subsoil, and to change of aspect and locality, it is either entirely absent over several acres and even one or more square miles, or appears in patches of several individuals together; but in any case, when a sufficiently large area is considered, its proportion scarcely ever exceeds 1 in 10, and is generally not more than 1 in 100. The associates of teak are, besides bamboos, the ordinary trees of the dry tracts of India. These of course vary in different parts, but the following kinds may be regarded as its usual companions:—*Ougeinia dalbergioides, Anogeissus latifolia, Diospyros Melanoxylon, Terminalia tomentosa, Dalbergia latifolia, Pterocarpus Marsupium, Lagerstræmia parviflora, Gmelina arborea, Schleichera trijuga, Cassia Fistula, Terminalia belerica, Buchanania latifolia, Semecarpus Anacardium, Garuga pinnata, Sterculia, Eriolæna, Cordia, Adina cordifolia, Careya arborea, Bauhinias,* &c., &c. To these must be added, in Burmah and some of the forests of the Peninsula, *Pterocarpus indicus, Xylia dolabriformis, Anogeissus acuminata,* &c.; in some parts of Central and Southern India, *Hardwickia binata*; and for the whole of Central India, the Deccan, and some portions of the Peninsula, *Boswellia thurifera.*

The following is a brief recast by Mr. Baden-Powell of the four subtypes of Burmese Teak Forest established by Dr. Brandis in his Attaran Report:—

(*a*). *Position.* Level, below hills or in valleys near higher hills as Beeling (Martaban).

Soil. Moist, good.

Companion species. Very various: *Lagerstræmia Flos-Reginæ* and *tomentosa, Dillenia, Bignonia,* &c., &c., and bamboos.

Undergrowth. Musa, Zingiber, Curcuma, Globba, and Acanthaceous plants.

Shade in Hot Season. Constant.

Fires. Not regular; not dangerous.

(*b*). *Position.* Lower undulating hills.
Soil. Moist, good.
Companion species. Bamboos in scattered clumps, *Xylia*, *Pterocarpus*, *Albizzia*, *Terminalias*, *Dillenia speciosa*, *Hibiscus*, *Bombax* and *Eriodendron*.
Undergrowth. Pollinia or Teak Grass, which dries and becomes inflammable.
Shade in Hot Season. Some.
Fires. Regular, destructive.
(*c*). *Position.* Lower undulating hills.
Soil. Poor and dry.
Companion species. Dendrocalamus strictus, Hibiscus, Xylia, Terminalia, &c.
Undergrowth. Little or none.
Shade in Hot Season. None.
Fires. Regular, but sparse undergrowth renders them light.
(*d*) *Position.* Higher hills.
Soil. Slopes with good soil.
Companion species. Evergreen Bamboos, *Xylia*, *Homalium*, *Terminalia*.
Undergrowth. Rather sparse; in places Acanthaceous plants, *Baliospermum*, &c., and Grass.
Shade in Hot Season. Some.
Fires. Occasional only, and not very destructive.

In India most of the companion species in this type of forest are leafless during the whole of the hot weather, while the growth is generally more or less open and the ground is hence nearly always covered with a close crop of grass from 1 to 12 feet high, which, owing to the dryness of the soil, becomes easily inflammable very early in the year. Moreover the pile of newly-fallen dead leaves on the ground is every year more than a foot thick and is highly combustible. The consequence is that, except where protection is specially undertaken, fires sweep annually through every square inch of the forest, burning up all the grass and the thick covering of fallen leaves, seeds and debris of branches, thus preventing natural reproduction, impeding the formation of humus, hardening, caking and baking the surface soil, and destroying or fatally injuring a large portion of the standing growth.

(iv). *Mixed Forests without Teak.*—This type of Deciduous Forest forms the connecting zone or link between Teak Forest, on the one side and *Hardwickia*, *Acacia Catechu*, Bamboo, Eng and especially Sal and the first, six, and ninth subclasses of Evergreen Forests on the other. Forests of this type vary greatly in their constituent species, which are, however, the same as those of the two types just described. Their limit is determined by the frequent inability of teak to extend itself, in numbers sufficient to form an integral portion of the crop, right up to the confines of Deciduous Forests of the remaining types

and of the Evergreen Forests already mentioned. Hence, as a rule, they occur only in patches or belts of limited extent separating Teak Forests from the rest. One of the largest of these areas, an exceptionally extensive one, is the Moharli *Pterocarpus Marsupium* tract in the Central Provinces, which measures about 400 square miles. As is natural to expect, they offer many subtypes according to the prevailing tree, which in one case is *Pterocarpus Marsupium;* in a second, *Ougeinia dalbergioides*; in a third, *Anogeissus latifolia;* in a fourth, *Terminalia tomentosa;* and so on.

On stiff binding soils *Terminalia tomentosa* forms under favorable circumstances a dense lofty leaf-canopy tolerating no undergrowth of any kind, and such patches are self-protected against fire to the same extent as Sal Forest. Otherwise fires are an annual visitation; but the injury done by them varies greatly with the predominant species, being, for instance, comparatively slight in tracts of *Ougeinia dalbergioides* and very severe in those of *Pterocarpus Marsupium* and of *Anogeissus latifolia.*

(v). *Eng Forest.*—This type is peculiar to Burmah and is so named after the principal tree in it, the ENG (*Dipterocarpus tuberculatus*). It has been divided by KURZ into two subtypes as follows:—

(*a.*) *True Eng Forest.*—This subtype occurs entirely on laterite on flat or undulating ground, and is marked by the complete absence of teak from it. The Eng is, of course, the predominant tree, but associated with it are *Dillenia pulcherrima, Shorea obtusa, Pentacme siamensis, Lophopetalum Wallichii, Zizyphus Jujuba, Buchanania latifolia, Melanorrhœa usitata, Symplocos racemosa, Diospyros birmanica, Dalbergia cultrata, Wendlandia tinctoria, Terminalia macrocarpa, Careya arborea, Strychnos Nux-vomica, Odina Wodier, Gardenia turgida, Eugenia Jambolana,* &c. *Dendrocalamus strictus* puts in an appearance, but only on the outskirts of the forest. Climbers are remarkable by their almost total absence. Shrubby and herbaceous growth is meagre and sparse. Where depressions occur, they are usually covered over with deposits of stiff clay inundated during the rains and more or less covered with thin grass and sedges. Fires occur annually, but, owing to the comparatively small quantity of combustible material on the ground, are not very destructive.

(*b.*) *Hill Eng Forest.*—This subtype occupies the ridges of the outer hills of Martaban and Upper Tenasserim, where they luxuriate either on laterite formed by the decomposition of the underlying rock or on débris of metamorphic rocks. In general aspect this subtype agrees with the one just described. But the Eng is often replaced or intermixed with *Dipterocarpus costatus,* and *obtusifolius,* and some other trees are met with such as *Engelhardtia villosa, Quercus Brandisiana* and *Bancana, Schima Bancana, Castanopsis tribuloides,* &c.

What is the nature of the undergrowth, and the prevalence and destructiveness of fires?

(vi). *Khair Forest.*—Forests of *Acacia Catechu,* associated frequently with sissoo, but more or less pure, are found in the Sub-Himalayan belt on islands and on the banks of streams near their entrance into the plains from the Indus to Assam.* The tree forms more or less pure forests also on dry sandstone hills in Central India and on alluvial soils at the foot of the hills in the Prome and Thayetmyo Districts in Burmah. In the Sub-Himalayan tract the growth under favorable conditions is at least fairly dense. This fact, combined with the nature of the soil (sandy and extremely wet during the season of vegetation), accounts for the usually very short and spare crop of grass and other undergrowth in these forests, and the infrequency and light character of fires. In Central India the growth is very open and stunted and the crop of grass comparatively heavy, with the result that very destructive fires occur annually, which render the khair crooked, shrubby and unsound.

Information required regarding the Sha tracts of Burmah. (Messrs Oliver and Pickard.)

(vii). *Hardwickia binata Forest.*—This species forms long belts or patches of greater or less extent of forest in some of the drier tracts of South and Central India. One great belt extends from a point west of Indore through Dhar, Nimar, Khandesh, Berar, Chanda and the Godaveri Forests into the Circars. Patches occur on the eastern slopes of the Pachmarhis, near the Dudhi river, on the Singroli hills south of the Sone River, and in Northern Mysore. Everywhere in this type of forest the *Hardwickia* is easily the predominating tree; but as it forms of itself very open growth, and throws little shade, there is always a certain proportion of species characteristic of the dry tracts of India associated with it:—*Anogeissus latifolia, Boswellia thurifera, Odina Wodier, Schrebera swietenioides,* teak, bamboo, *Diospyros Melanoxylon, Pterocarpus Marsupium, Soymida febrifuga, Terminalia tomentosa,* &c.

The undergrowth consists chiefly of *Nyctanthes Arbortristis,* which forms dense thickets, *Acacia Catechu, Mimosa rubicaulis, Gardenia turgida* and *lucida, Zizyphus xylopyra, Randia dumetorum, Celastrus senegalensis, Flacourtia Ramontchi, Kydia calycina, Helicteres Isora, Cochlospermum Gossypium, Balanites Roxburghii* and *Grewia pilosa* and *asiatica*; and the undershrubs *Grewia polygama* and *Desmodium gangeticum* are very common. The growth of grass is very variable, being from dense and rising up to a height of 8 feet on the richer and deeper soils to rather spare and from only 9 inches to 2 feet high in dry rocky situations. This grass dries up between October and February, and all the companion species shed

* See footnote to page 373.

their leaves within the same period, and do not renew them before the middle or end of June. Thus fires rage from October to the commencement of the rains and are very destructive.

(viii). *Bamboo Forest.*—This type is largely developed in Burmah, in Eastern Bengal and in Assam, and partially in Central India and in the Peninsula. It is characterised by great uniformity of aspect and by the poverty of the undergrowth, shrubby as well as herbaceous, due to the dense leaf-canopy above and the invasive nature of the root apparatus of the bamboos. We seldom find more than two kinds of bamboo together, and we thus have subtypes according to the prevailing species, after which they may be named. Single species frequently cover enormous areas, as for example in the Garo Hills, where, out of an area of 600 square miles, at least half is covered by the "Terai Bans," which forms the densest growth imaginable, occasionally reaching a height of 40 feet. On a very much smaller scale the Kattang (*Bambusa arundinacea*) and the *Dendrocalamus strictus form patches or belts of* from ½ to 15 squares miles of more or less pure forest in the North-West Provinces, in Oudh and in Central India.

As in each bamboo clump some shoots die every year, and the layer of dry fallen leaves is very thick, there is always a large quantity of highly combustible material in these forests, which renders fires an annual and very destructive visitation. But when the gregarious flowering begins and the clumps die off wholesale, the fires become quite uncontrollable and the whole crop of seed is sometimes destroyed.

The species sometimes associated with the bamboos vary according to the locality, but are generally the same as those which grow in the neighbourhood and belong to the types of forest already described.

When the bamboos have seeded and died off simultaneously over a large area, numerous seedlings of hardy shrubs and trees spring up with the bamboo seedlings and contend with these latter for supremacy, and not unfrequently gain the upper hand, keeping down the bamboos as an undergrowth.

(ix). *Anogeissus pendula Forests.*—This type consists of large stretches of almost pure forests of *Anogeissus pendula* (*Dhaukra*) clothing the dry submetamorphic hills of Ajmir and Marwar, of Meywar, Bassi, Chitor, Bundelkhand, &c. The principal companion species are khair, *Bauhinia racemosa*, *Boswellia thurifera*, *Ehretia lævis* and *obtusifolia*, *Dalbergia lanceolaria*, *Anogeissus latifolia*, *Euphorbia Nivulia*, *&c.*

The growth is under favorable conditions, as a rule, extremely dense and bushy, and seldom exceeds 35 feet in height. The shrubby undergrowth consists of several small species of *Grewia* (*villosa*, *populifolia*, *salvifolia*, *asiatica*, and *pilosa*) *Rhus mysorensis*, *Plumbago zeylanica*, &c. The crop of grass in the

glades and blanks is short and spare, and dries up by November. Fires there are hence regular occurrences, and, in spite of the light growth of the grass, are extremely severe owing to the long dry season and the high temperature of the hot season. They are also severe in the close-grown portions, as the *dhaukra*, being very nearly pure and out of leaf from April—May to the first week of the rains, the ground gets covered in the hot weather with a thick covering of dry leaves, which burns up fiercely when ignited, the fire rising to the top of the low-crowned trees and killing and injuring innumerable buds, twigs and branches. Under these circumstances it is uncommon, in spite of the profuse annual seeding of the *dhaukra*, to find any noticeable quantity of young reproduction, and the trees grow stunted and branchy.

(x.) *Melanorrhœa usitata Forests.*—This has been suggested to me as a type by a Forest Officer from Burmah. As I have no experience whatsoever of that province, would foresters there kindly favour me with a brief description of the type in question, bringing out all its main characters?*

CHAPTER IV.—*Creation and Regeneration of Forests,*

SECTION 1.—DEFINITIONS.

A forest may be created or regenerated either ARTIFICIALLY or NATURALLY, or by both means combined—ARTIFICIALLY by means of DIRECT SOWING or PLANTING, NATURALLY by means of SELF-SOWN SEEDS, STOOL-SHOOTS or SUCKERS.

In DIRECT SOWING, as the term implies, the seed is placed in the ground in the forest itself which is to be created or regenerated, and at the very point which the seedling is finally to occupy.

PLANTING may be distinguished into PLANTING PROPER, and PLANTING with SLIPS and LAYERS, SUCKERS and RHIZOMES.

In PLANTING PROPER seedlings raised at, and brought from, some other point are used in the place to be stocked.

A SLIP † is a severed branch or stem, a certain or the whole length of which is put into the ground where it strikes root. SLIPS may either, like seeds, be placed out at once

---

* The reader will now have seen how necessarily imperfect and sketchy the Notes given in this Chapter are. To do justice to the subject of it would require a long and thorough familiarity, such as no ordinary being could acquire even in a whole lifetime, with the multifarious forest forms of a continent like India, which comprises within itself nearly every imaginable variety of soil and climate. My only hope is that I shall meet with the hearty co-operation of all Indian foresters, whose combined experiences it will be possible to harmonise and embody together when the present Chapter comes to be finally written. I address my appeal more especially to Southern India, which is as yet a completely unknown land for me.

† The term more generally in use is "cutting," but this word also denotes felling, or the removal of the whole or a portion of a standing crop. I have hence, to avoid an ambiguous terminology, preferred the less usual noun "slip," from which we derive the verb "to slip," and the noun "slipping" meaning respectively *to propagate by slips* and the *operation of propagating by slips.*

where they are required, or, like seedlings, they may be raised elsewhere and removed thereto only after they have struck root.

LAYERS are also branches, which are, however, at first bent and pegged down into the ground at some point below their growing extremity, or enclosed for a part of their length within a ball of earth, and are severed from the parent stem only after they have struck root.

To TRANSPLANT means simply to remove a plant from any one place to any other.

A TRANSPLANT is any rooted plant used in planting.

A NURSERY is any area specially set aside for the raising of transplants.

To PICK OUT a plant is to remove it from one point of the nursery to any other, while to PUT OUT a transplant means to place it in the ground in the forest at the point itself which it is finally to occupy. *To pick out* and *to put out* are thus *only two special cases of transplanting.*

To UNDERPLANT is to plant under an existing taller crop.

A SEEDBED is any cultivated portion of a nursery in which plants are raised from seed sown *in situ.* Before transplants are put out, they are often removed from the seedbeds and planted out in regular lines in the nursery itself, such lines being termed NURSERY-LINES.

SECTION 2.—NURSERIES.

Whatever method we adopt for the creation or regeneration of a forest deserving of the name, the establishment of a nursery is indispensable. If planting is resorted to, the necessity of a nursery in which to raise the transplants is obvious. However successful natural regeneration may be, however conscientious or skilful the care and precautions taken in executing direct sowings, there will always be spots of less or greater magnitude in which seedlings will die off or refuse to come up, or in which stools will be unproductive, or in which a given valuable species will be absent or insufficiently represented, in which, in short, the early establishment of plants of a certain species and of a given size and vigour will be urgently required. In all these cases a nursery must be at hand from which a supply of such plants is immediately available. In a nursery all the plants receive individual attention, and it is there alone that they can be raised under the most favorable conditions possible for any required purpose. How to establish a nursery is, therefore, the first question that requires to be answered. In doing so, I will consider the subject under the following nine heads :—

(1). Choice of site.
(2). Area of nursery.
(3). The form of its boundary.

(4). Fencing.
(5). Watering.
(6). Preparation of the soil.
(7). Laying out of beds, paths, &c.
(8) Collection and storage of seed.
(9). Preparation and management of seedbeds and nursery lines.

Before proceeding to discuss each of these points separately, it is necessary to premise that nurseries may be either TEMPORARY or PERMANENT according to the purpose which they are to serve. For instance, heavy planting operations are undertaken over a large area, and carriage is expensive; in this case it may be found advantageous to make several temporary nurseries, each to supply the transplants within a certain radius of itself, and to be abandoned immediately afterwards. Or, again, a large blank is to be restocked, near which there is an excellent site for a nursery, but which is situated at some distance from the regular nursery serving the forest; here also it might be profitable to utilize the site in question in order to raise just the number of plants required. And so on.

It is evident that once a nursery is established, it can be maintained indefinitely without any further expenditure on the preparation of the soil, on fencing, and on the supply of means for watering it, except what is necessary for mere repairs. This expenditure is always comparatively heavy, and is incurred once for all in a permanent nursery, whereas it constitutes a fresh charge each time a temporary nursery is made. Moreover a permanent nursery can, for obvious reasons, be managed more efficiently and also more economically. Hence the only advantage which lies on the side of temporary nurseries is reduced cost of transport; and consequently, whenever there is any question of establishing this class of nursery, it must first be proved that the saving on carriage is not more than counterbalanced by what would be gained in efficiency and in reduced charges on the raising of the transplants in a permanent nursery.

§ 1. PERMANENT NURSERIES.

§§ 1. *Choice of site.*

In choosing a site for a permanent nursery, we have to consider its two elements:—(i) soil, and (ii) locality.

With respect to the first, it is an exploded idea that transplants should necessarily be raised in soil similar to that of the forest into which they are put out. What we require is nothing more or less than vigorous plants well furnished with fibrous rootlets and with a crown strong in proportion, and that soil is the best for our purpose which produces such plants, whether it be like the soil of the forest or

not. Such a soil suitable for almost every species is one of a medium quality, which is neither too rich nor too poor, neither too wet nor too dry, neither too stiff nor too free ; in other words, it should be a moist sandy loam that is free from stones and sufficiently deep. If it should happen that soil of this character is not available, then it is better to select a sandy soil than one which contains a strong proportion of clay, which in drying would cake at the surface, and shrink and crack, thus rending asunder and killing the roots of the seedlings, and which during frost would swell up and then eject them as soon as thaw occurred. The sterility and want of sufficient cohesion of a sandy soil can be easily cured by admixture of the necessary manures, whereas it would be a difficult and expensive task to correct the defects of stiff clays. Moreover, a sandy soil is much more easily kept clear of weeds. As regards depth it does not follow that because the transplants ought to possess short roots, not exceeding say 18 inches in length, the depth of the soil should also be limited to that figure. With such a slight depth, the soil would nearly always be exposed to be overheated under a hot sun, and it is always safe to insist on a minimum depth of 3 feet. Stones in the soil also tend to overheat it, besides injuring the nursery implements and interfering with the easy lifting up of the plants.

The nature of the subsoil is of little importance as long as it is not impermeable or too freely permeable. A basis of lime is an advantage, as it prevents the formation of acids in the soil, while at the same time it enriches it.

Here I must note the exceptional case of the sissoo plantations recently started by Captain Wood. After several failures in attempts to restock with sissoo certain areas, which are now grasslands interspersed with a few scattered sissoo trees, standing alone or in small clumps, but which formerly bore a good forest of that species, Captain Wood very rightly came to the conclusion that the roots of the sissoo seedlings he put in were unable to cope with the dense mass of roots of the grasses already in possession of the ground. He, therefore, conceived the idea of using seedlings with a tap-root long enough to reach soil below the layer monopolised by the roots and rhizomes of the grasses. The results of several trials during the past three years gives hopes of success with taproots from 4 to 6 feet long. But to obtain seedlings with taproots of such great length, which can be preserved uninjured during lifting and transporting to the forest, the transplants must evidently be raised in special pots or receptacles ; it is possible that raising in pots may, for one reason or another, be found necessary in a few other cases besides that of sissoo in Oudh. The foregoing remarks, however, do not in any way vitiate or modify the general observations made in the preceding paragraphs.

With regard to the second point, locality, it may be generally

laid down that it should not be one exposed to early frosts or to drought, nor ought it to be so damp as to favour the development of mildew and other fungoid growth. Moreover it must not be confined in the midst of a lofty mass of forest. It should be just sufficiently inclined to allow water to drain off easily, without, on the other hand, letting it out too fast. In hilly country, however, steep ground cannot of course always be avoided, but even with a high gradient soil that holds water sufficiently well can invariably be found. Lastly, it is a great convenience to have a surface spring or streamlet near at hand from which to irrigate the nursery, especially if it runs above the latter and can be diverted into it. The vicinity of a tank above the level of the nursery is still more to be desired. In the absence of such a spring or streamlet, a well or wells must be sunk, in which case the water-holding stratum ought to be as near the surface as possible. Occasionally flat expanses of good soil high enough to be beyond the reach of damp frosts can be found along the banks of small rivers, which run all the year round or contain perennial pools, thus saving the expense of well-sinking.

No trees should be allowed to stand in the nursery, nor any so near its boundary as to interfere by means of their roots with the cultivation of the ground inside. A belt of trees along the boundary, producing useful seed and sheltering the nursery against cold or scorching winds, is always desirable.

The accessibility of a nursery is a matter of the first importance. In the plains always, and in the hills whenever possible, carts ought to be able to come up to the nursery. And for the forest or forests which it has to serve, the nursery should occupy the most central position available.

§§ 2. *Area of Nursery.*

The area of a permanent nursery ought, generally speaking, to be at least large enough to occupy fully the time of any special establishment entertained for it. It will of course vary with the area of the forest or forests which it has to serve, with the extent to which artificial methods of stocking or regeneration are resorted to, and with the average age and size of the transplants to be raised. It must be borne in mind that the labour and cost of establishing and maintaining a single large nursery is much less than that required for a number of small nurseries aggregating the same area, except that in the former case the transplants have to be carried out over a longer distance. Nevertheless, unless the distance of lead is very great, the extra cost of carriage per individual plant is insignificant, and in nearly every case it is expedient to have a large nursery. It may, therefore, be laid down as a general rule that the area of a permanent nursery should not be less than 4 acres, and in the majority of instances it should be at least 6 acres.

§§ 3. *The Form of its Boundary.*

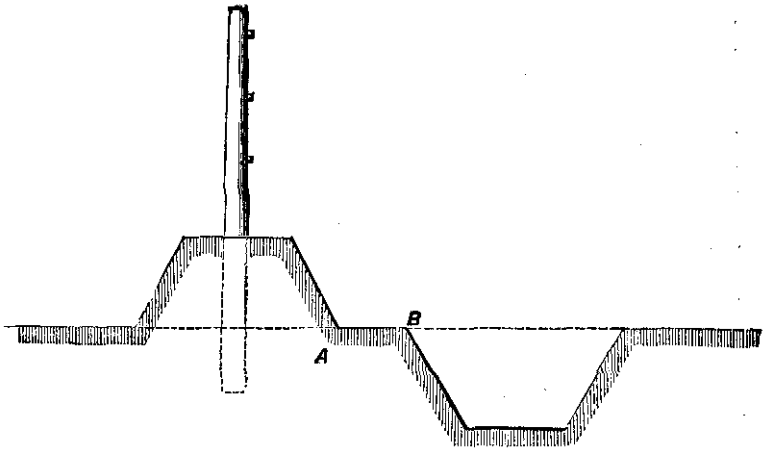
On the outer form of the nursery depends the length of its boundary, and hence the cost of fencing it. It should, whenever possible, be a regular figure. The circle would be the best form to adopt, since for the same length of periphery, it encloses the largest area of any other; and after the circle the equal-sided polygon. But neither of these figures are of any practical value, since the arrangement of the irrigation channels, and hence of the beds and paths, must always be rectangular, and would consequently lead to a great waste of space at the circumference. Hence the best figure would be the square. In many cases, however, as in the hills, the choice of site is limited, and there is no alternative but to adopt rectangles and even irregular figures. Exceptionally indeed there are even occasions in which irregular figures are advantageous, as where a portion of the boundary coincides with the bank of a river which forms a natural fence.

§§ 4. *Fencing.*

No nursery can fully serve its purpose unless it is completely protected against the inroads of cattle, elephants, pigs, porcupines, hares, deer, bears, and other destructive animals.

Where flat stones are procurable, in the vicinity and in abundance, as in most districts of sandstone and gneissose formation, a wall of dry masonry, effective in every way, can be put up at a trifling cost. A pucca wall would of course be the best, but the expenditure required for its construction would, in most cases be prohibitive. The next best kind of fence would be one of wire stretched on standards of iron or wood or better still on single slabs of stone. Such a wire fence has, however, this disadvantage that it does not stop the ingress of small animals, such as hares, porcupines and even young pigs. But if funds are available, that defect is easily remedied by means of wire netting, or, in the contrary case, by putting up against the wire fence a thorn fence formed of branches of *Zizyphus*, khair, or any other spiny bushes abundant in the vicinity, similar to those erected every year round fields in most parts of India. The branches should be inserted a few inches in the ground by their lower extremity and secured to the wires with slips of fibrous bark or with withes, the whole work being executed without any extra expenditure by the nursery establishment during their many leisure half-hours. The wire fence just described would with most advantage be erected on a mound formed by excavating an open ditch about 18 inches deep and 2 feet wide along the boundary and throwing up the earth along its inside edge. The sections of both the mound and ditch should be an equal-sided trapezium as shown in the annexed diagram, and would

necessarily be equal in area. A *berm* or *scarcement*, AB, should



be left between the mound and ditch to prevent the earth slipping from the mound into the latter. The mound should be thoroughly well beaten down before the fence is put up. The advantage of the combined mound and ditch is that they reduce the height of the wire fence required, while the ditch, besides serving as an additional protection, also performs the office of a drain. When the nursery is situated on a pronounced slope, the ditch and mound cannot obviously be employed, since they would only facilitate the erosion of the soil. On such slopes no special protection will be required along the lowest edge of the nursery, since the retaining wall of the lowest terrace (see §§ 6) would be as good as a sunk fence.

All tight-bound fences of wooden posts and wattling are entirely out of place in this country, where white ants and destructive weather influences would necessitate their constant renewal. Moreover they would be no barrier to pigs, porcupines and hares.

Live hedges of species varying with the forest region may be employed when the area of a nursery is very large, which would be the case if the nursery were used also as an experimental forest garden. But, in any case, more effective internal fences would be required for the portion of the area devoted to real nursery work. Live fences have for the most part this prohibitive disadvantage that they harbour noxious vermin, besides, when not thorny, giving free access to hares, &c. The principal species best adapted for live fences are—in the Himalayas, *Cratægus*, *Pyrus variolosa*, roses; in the plains, species of *Euphorbia*, *Zizyphus*, *Carissa*, *Cæsalpinia*, and *Acacia*, the prickly pear and American aloe, bamboos, *Capparis horrida*, &c.

Elephants can be kept out only by means of *chevaux de frise* supplemented with sharp-pointed stakes driven into the ground along the outside.

§§ 5. *Watering.*

In the climate of India, which admits everywhere of a more or less prolonged Dry Season, watering in some form or other cannot be dispensed with. Even in the few exceptional cases in which the intervals between sufficient falls of rain are not long enough to kill the young nursery plants outright, these, especially those in the seed-beds, are thrown back in their growth, unless watered artificially. And in any case it is always an indispensable advantage to be able to control the growth of the young plants without being entirely dependent on the contingency of rain falling.

Admitting then the necessity of artificial watering, we may generally lay down the rule that for nursery purposes the usually soft tepid water of a flowing stream is better than the generally hard chill water of a spring. Obviously tank water is even better adapted for the nursery than that of a flowing stream.

The chill of cold water is easily corrected by storing it in a reservoir previous to use. This storing also affords an opportunity of mixing special soluble manures with the water, which expedient, as will be seen further on, is often useful and even necessary. The reservoir, to minimise waste by absorption in the soil, by evaporation, &c. should be situated in the immediate vicinity of the nursery.

Water may be given to the plants either (A) by pouring it from above, *i.e.* by HAND-WATERING, or (B) by IRRIGATION.

(A). In hand-watering the supply of water may be brought either in skins or be led in channels from wells or tanks or running streams into reservoirs, either of pucca masonry or with merely puddled sides and bottoms sunk in the midst of the beds or lines to be watered. Hand-watering is under all circumstances both costly and slow, and when once begun has to be continued nearly every day until the first fall of rain thoroughly soaks and loosens the soil. When it is effected with watering-pots or ordinary garden pumps, a hard crust, impermeable to air and dew, forms on the surface of the soil, which crust has to be broken up by light hoeing as often as the watering takes place. This objection is obviated by the use of the garden syringe, which consists of a forcing pump whose spout is furnished with a fine rose; through this rose the water is ejected with great force in minute drops like rain, which wash off the dust, &c. clogging the green parts of the plants. Whether pots or pumps or syringes are used, the water ought to penetrate as far as the roots to produce any useful effect.

Hand-watering in permanent nurseries has its *raison d'être* only in the hills where drought is neither prolonged nor severe, and even then only in the absence (exceptional it must be said) of running streams or surface springs immediately above the nursery site.

(B). In all other cases irrigation should be resorted to: it is much cheaper, much more effective and much more expeditious. The ordinary system with the European nurseryman is to lead the water, from whatever source it is obtained, into horizontal channels running between the beds and lines parallel to their longest dimension, and retaining it therein by damming up every outlet until the soil of the beds or lines, as the case may be, is thoroughly drenched, without the water ever flowing into them. By this last precaution the formation of a superficial crust of mud is avoided. For convenience sake I will term this the SIDE-DRENCHING system.

A common method employed by native gardeners and agriculturists is to enclose the beds and lines by a continuous ridge of earth 5 or 6 inches high and to flood them with 3 or 4 inches of water. By this means the soil is perhaps more effectively drenched, as more water can be thus given in a single operation, and, moreover, there is no loss of time as in the side-drenching system, in which the nurseryman has generally to wait until one line of beds has absorbed moisture completely before he can proceed to water the next row of beds; but, on the other hand, the formation of a superficial crust of mud, which must afterwards be raked and broken up, is inevitable. The water let into the beds sometimes stands as much as one hour before it is completely absorbed by the soil. The method just described may be termed the FLOODING system.

Whether the side-drenching or flooding system be employed, the effect is the same as regards the total destruction or banishment of white ants, rats, mice, and most other burrowing animals, the depredations of which seem only to be aggravated by hand-watering.

Another advantage which irrigation possesses over hand-watering is that it succeeds in shallow soils where the latter fails.

Although implied under the head of site, it may be stated here that the spring or tank, from which the water-supply is obtained, should not be so near the nursery as to keep the soil constantly in a thoroughly saturated state, which would not only directly injure the growth of most species, but also produce severe damp frosts.

When a tank, spring, or stream is on a lower level than the nursery, the water has obviously to be lifted. Of the various water-lifts in use in India the best are the Persian Wheel (of which there are several forms), the Double *Mot*, *Charas* or *Charsa*, the *Dheki*, *Dhenkli* or *Dhenguli* and the *Lathi Kundi*, which will all be found described with sufficient detail in the Appendix. The water thus lifted can be led away at once into the nursery beds and lines, or stored up in a reservoir until wanted. When the distance of lead is considerable, say exceeds 50 yards, iron pipes, or cheaper still, gutters of wood or sheet

iron, supported on wooden or iron trestles, are easily and economically set up. Masonry channels, if on a large scale, are extremely costly, and earth embankments, however well puddled, are very wasteful, and require constant looking after.

In the absence of all other sources of water-supply, the only plan is to sink wells, the number and size of which will depend on the area of the nursery and the abundance of water in the stratum in which they are sunk. The most effective water-lifts to employ in this case would be the Persian Wheel and *Double Mot.*

The best time for watering is, according to the experience of Indian gardeners and agriculturists, the afternoon.

The explanation of this, as far as the hot weather is concerned, is obvious, for watering early in the day would result in a very large proportion of the water being lost by simple evaporation. But as regards the cold weather, in places exposed to night frosts, it is evident that the later a plant is watered, the larger will be the quantity of moisture contained in its tissues, and hence the slighter its resistance to frost during the night. And not only this, but the increased humidity of the air in which the plant is bathed is bound to aggravate the severity of the frost. Hence the proper plan in the cold weather would be to perform the watering in the forenoon; and if from wells, since well water is always much warmer than the air and the soil in the morning during that period of the year, as early in the day as possible. But, whenever practicable, watering ought to be entirely dispensed with in frosty situations during the Cold Weather.

When there is advantage in watering in the afternoon, the whole or portion of the water-supply that is available in the forenoon can, if necessary, be stored up in reservoirs. Such storing is unavoidable when the discharge of the canal or natural stream, on which the nursery is dependent, is insufficient to irrigate the required area within a given time.

§§ 6. *Preparation of the soil.*

The first thing of all to do is to clear the ground of every tree and shrub, and to grub out the stumps and principal roots. *The best implements to use for this purpose and the* most expeditious and economical method of effecting it need not be described in a work on Sylviculture, since the art of felling trees and extracting stumps and large roots belongs to another branch of Forestry, under which it will most appropriately be treated.

Next, the ground must be levelled. In the plains, if the surface of the soil is more or less even and has only a slight slope, and provided the length of the nursery in the direction of the slope is not great enough for there to be any very appreciable difference of level between its lowest and highest

portions, this end is accomplished simply by means of the ploughing operations followed by a few sufficiently heavy falls of rain. The deeper depressions must, however, be filled up with good topsoil brought from outside the nursery.

If, all other circumstances being the same, the difference of level is marked, exceeds say 4 or 5 inches, the site of the nursery must be divided off into horizontal terraces, the edges of the terraces being protected against slipping or erosion by means of retaining walls of dry masonry. Pucca walls, being necessarily built on solid foundations, would be excessively costly, and also have the drawback of impeding a free drainage.

The labour of terracing will obviously be directly proportional to the tangent of the angle of slope, and the width of the terraces will equally obviously vary jointly with the angle of slope, and the depth and richness of the topsoil. Moreover, in forming the terraces the height of each terrace ought to be so chosen that the cutting shall, as far as practicable, be equal to the quantity of embankment, in order thereby to minimise both the labour of cutting and the distance of lead for the earth cut, and to utilise every bit of this latter.

The use of a levelling instrument is always indispensable, as the best work with the eye cannot but fail at many points, and cause hereafter much annoyance and heavy expenditure on frequent repairs of broken terraces and eroded soil.

Under any circumstances, we cannot, in India, get rid of the necessity of protecting the soil against erosion, since every year heavy falls of rain occur, a large proportion of which, not being able to enter the soil as fast as it falls, rushes off the surface, cutting channels through it, and carrying away a considerable portion of the top-soil, especially if this has been loosened by cultivation.

Whatever the character of the ground, the following rule should be universally observed:—The rain falling on higher land outside the nursery should in no case be allowed to run down into the nursery, nor ought any portion of the rainfall within the limits of the nursery to be permitted to be carried off outside by *surface* drainage.

In the plains, the mound system of fencing, already described on page 425, answers perfectly as a protective work. The mound prevents a rush of water both into and out of the nursery; while the ditch serves not only to drain off with sufficient rapidity any excess of moisture in the soil of the nursery itself, but carries off all the surface drainage of the higher ground outside. Indeed, when the fall of the ground does not exceed about 1 in 200, the mound alone is so effective that it is common to see large fields as it were walled off by mounds of mere earth into a number of very nearly level compartments. Any slight difference of level that exists is soon

corrected by rain, and the compartments form a succession of low terraces with earthen parapets.

In the hills, besides supporting the terraces by a retaining wall, as already described, a violent rush of water over the edges, and the consequent washing off of the soil, is prevented by sloping the terraces slightly inwards. The rain falling on the slopes above, if they comprise an area large enough to receive an appreciable fall during a single shower, can be easily diverted by means of one or more channels into the nearest ravine or gully.

The next point to attend to, after clearing and levelling the ground and protecting the soil against erosion, is the freeing it of all its larger coarse elements down to 18 inches at least below the surface. The object of this operation is to have the soil contain nothing that would blunt the sharp implements of the nurseryman, and also to give it a uniform texture.

First of all, the stones lying on the surface ought to be picked off; those below the surface are got rid off during the progress of the actual tillage. Where the stony element is at all abundant, some of it will still remain, and will have to be removed by sifting when the nursery beds and lines are prepared, as explained further on.

Lastly, we have to consider the tillage or real preparation of the soil, the object of which is to kill out the roots of all existing growth and to loosen and, if necessary, to correct the defects of the layer of the soil that is to contain and nourish the roots of the plants to be raised. In thus breaking up the soil, care must be taken to bring up to the surface as little as possible of its under layers, which have never been exposed to fertilising weather influences.

If the operations preceding the tillage have not already removed the low vegetation that covers the ground, this should now be got rid off. Amongst native gardeners and agriculturists it is usual to burn off this low vegetation. This plan is to be deprecated (except on acid or stiff clayey soils, which should in the first instance never be chosen), as its only recommendation is a very petty economy; it not only destroys the organic matter in the top layer of the soil, but also bakes the latter. There is no alternative but to use the grubbing axe, scythe or sickle, and to carry away out of the nursery area or to the manure pit all the rubbish cut. Nevertheless, if the quantity of this is not considerable, it may be collected into small heaps up to a foot high scattered all over the area, and fired on a calm, dry day so as to ensure complete combustion. The succeeding tillage operations will suffice to mix the ashes thoroughly with the soil. Half-burnt remains of the rubbish are always strongly acid, and, if introduced into the soil, their decomposition during the first ensuing rains will, by reason of the heat thereby developed, also affect injuriously growing vegetation on it.

The deeper the soil is turned up, the better; and hence, theoretically speaking, the pick or hoe is the best implement for the purpose. But the progress of work with those implements is very slow, and, except on narrow terraces on steep hillsides where no other implement could be used, they must always yield the place to the plough. Whatever the pattern of the plough employed—and this varies greatly in different parts of India—the share must enter the soil deep enough to tear up completely once for all the vivacious roots and underground stems of existing vegetation. If any of these are allowed to remain in the ground, they will soon multiply and render the nursery work impossible. The creeping roots of woody species that throw up suckers cannot, however, always be got rid of with the plough, as they often (*e.g. Phyllanthus Emblica, Boswellia thurifera, Ougeinia dalbergioides, Diospyros Melanoxylon,* &c.) go down to a depth of 2½ feet and more, and hence the only way to deal with them is to dig them out one by one with a pick or hoe wherever a sucker or stump shows itself.

Deep cultivation is justifiable for the following four reasons :—(i) It is the only way to kill out all existing growth and to clear the soil of all roots and underground stems. (ii) The layer of soil, in which the roots of the seedlings to be raised are to spread and be nourished, can never be sufficiently loosened. (iii) This loosening of the soil is absolutely necessary in order to admit air, with its carbonic acid and nitrogen compounds, into the lower layers and thus fertilise them. (iv) While it prevents a sudden excess of damp in the layer of the soil occupied by the nursery plants and preserves them from what has technically been called *wet feet*, it also helps to preserve moisture in it during drought and to encourage the formation of dew in its innermost layers during the Cold Weather.

The best time of the year to begin ploughing is the Cold Weather : the soil is then still soft and yielding, and the sun is quite strong enough, or the cold great enough, to destroy the vitality of the roots and underground stems turned up. One or two women or boys should follow the plough and pick or pluck out all stones and roots brought up to the surface. If the land has had woody growth on it, the ploughman should be armed with a light axe with which to cut through all roots sufficiently strong to arrest the progress of his plough. A coulter fixed to the shaft of the plough, and strong enough to cut through woody roots 1¼ inch thick, will facilitate and expedite the ploughing work very considerably.

This first ploughing should be repeated at least twice, each time in a direction at right angles to the preceding one.

Fragments of roots and underground stems will, however, still remain in the soil, and the next operation will be to work it successively in two directions at right angles to one another

with the bullock-hoe, the size of which will be proportionate to the depth to which the plough has penetrated. This hoeing will break up the larger clods and bring up to the surface nearly all the roots remaining in the soil, which, together with stones, must be picked off as before, as soon as they show themselves. The clods are still further reduced by means of a log-roller or a special clod-crusher drawn by oxen. After this, it is advisable to hoe the soil over again in the same manner as on the first occasion.

The soil should then be allowed to lie thus until the first fall of rain has thoroughly soaked it, when it should be hoed over once more in the same manner as before. The result of this last hoeing will be that all the last clods, large and small, will be thoroughly broken, the soil acquire a soft, uniform texture, and the surface be evenly levelled.

The entire area of the nursery ought to be cultivated in the manner described, *i.e.*, not only the portions that are to compose the future seed-beds and lines, but also those which will constitute the roads and paths. As said before, the smallest remnants of vivacious roots and underground stems left anywhere in the nursery will soon multiply and spread, and not only cause much trouble and expense afterwards, but also impair efficiency very materially, and unfit a considerable portion of the area for the purpose for which it is required.

If the soil is poor in bases, as when it is a stiff clay or a nearly pure silicious sand, it is advisable to strew quicklime or, which is generally more economical, finely ground *kankar* over the surface just before the last two hoeings. The quantity of lime or limestone to use will depend on the nature of the soil in each particular case. Beyond the liming no manures should be applied until after the nursery beds and lines are laid out.

It is much to be recommended to grow a previous crop or two of potatos, Indian corn, rice, *Sorghum*, sugarcane, sesamum or cotton, whichever is the most suitable, before laying out the area as a nursery. The cultivation of such crops, which require very thorough weeding, effectually clears the soil of every trace of the previous vegetation that covered it, corrects all its harsh qualities, loosens it thoroughly, renders its texture perfectly soft and even, and completes the levelling of the ground. Potatos, sugarcane, and cotton are the best crops for our purpose, as cereals and oil-seeds attract rats and mice. While improving the soil and site, these crops will, besides, yield a large money return.

§§ 7. *Laying out beds, paths, &c.*

In laying out the interior of a nursery two main points have to be kept in view: (a) how to make the best use of the given area, and (b) how to perform the watering in the most economical and effective manner.

For every permanent nursery there should be a good set of offices for the establishment and for storing implements, seeds, &c. If the area is large, these buildings should be situated at or near its most central point in order to facilitate constant supervision both by day and night. If the area is limited, they should be erected immediately outside, and this can obviously, for the very reason that the nursery is small, be done without in any way impairing efficiency. The cattle used in connection with a nursery ought invariably to be stalled outside.

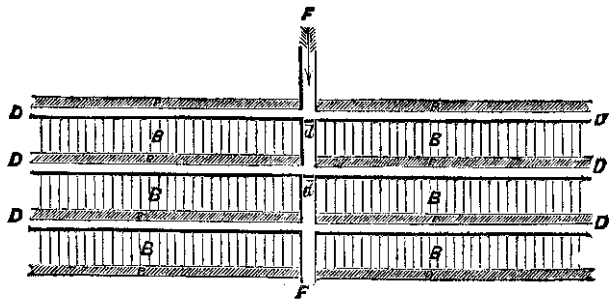
In large nurseries it is generally advantageous to have a cart road leading up at least to the nursery buildings, and, if possible, also carried further on, so as to bring it within easy reach of every part of the area. To economize space as well as money, it is expedient to give it only sufficient breadth for a single cart, but widening it at its extremity so as to enable the cart to turn. This road should be metalled and have a slightly convex section. Besides this, it ought to be raised somewhat above the level of the adjoining soil, and be protected with well-made side-drains. One corner, the shadiest and most protected of the nursery, ought to be specially set aside for preparing and storing manures.

The next step is to lay out the paths and nursery beds. These latter should be just broad enough for a boy, 9 or 10 years old, to reach the middle with his hand without having to step on them. A breadth of 40 inches is very convenient. Their length need have no limit, except what is fixed by the shape of the ground, and by the number of plants of each single species to be raised. Their shape ought always to be rectangular. The beds must be divided off from each other by paths about a foot wide, which will thus consist of two sets crossing one another at right angles. One of these sets of paths ought to abut perpendicularly on the cart road, when there is one.

When the nursery is to be irrigated, the paths running parallel to the longest dimension of the beds should follow horizontal lines, and the water should be led from the source whence it is obtained into a primary or FEED channel or channels, as the case may be, of sufficient width and depth, and cut between two groups of beds at right angles to that direction. Smaller DISTRIBUTING channels at right angles to, and on each side of, the feed one, and about six inches wide and four inches deep, should be hollowed out between each bed and the path adjoining it on the side from which the water comes down the latter. In Europe the paths themselves serve as such secondary channels; but in India, where large quantities of rain fall within a limited time, the paths, if used as watercourses, would be rendered quite unfit for circulation, and any attempt at circulation would, in turn, render the paths unfit as channels for distributing water. It is then evident that in this country it will always be expedient to beat the paths firm

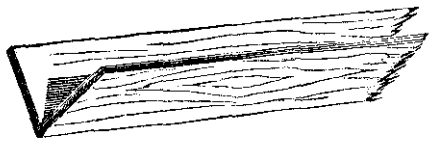
and to gravel them. The end of the distributing channels not connected with the feed one must be kept permanently closed.

In the side-drenching system of irrigation the surface of the beds ought evidently to be slightly raised above the paths, say about 2 inches. This is easily done by cutting a portion of the top soil off the paths and throwing it on to the beds. The adjoining distributing channels act as side-drains during a shower of rain, and protect the paths from being washed away. The water for irrigation is retained in the distributing channels, until the adjoining bed or beds are thoroughly soaked, by means of small removable dams consisting of a single piece of wood, earthenware, sheet iron, or stone fixed across the feed channel in a continuous line with the lower edge of the distributing ones, and just a fraction of an inch below the level of the paths, so that before the water could rise up to the top of the beds, it would flow over the dams down the feed channels. On even open ground the disposition of the beds, paths, and channels would be as represented in the adjoining diagram, in which B B are the beds, P P the paths, D D the distributing channels, F the feed channel, and d d the dams.



When the dimension of the nursery in the direction of the length of the beds is too great for a single system of feed channel with its distributors to perform the irrigation conveniently and efficiently, there must be more than one such system laid out; and, when this is the case, the feed channels should themselves be fed from a main one running at right angles to them at the highest end of the nursery. On hill sides the feed channels on each terrace must receive their water directly from those immediately above them; and hence, to prevent erosion, it is necessary to pave them, if not along their whole length, at least at both their extremities. In the hills flat stones adapted for this purpose are, as a rule, easily obtainable, and both the sides and bottoms of these channels can be protected with such stones at a trifling cost. But a simpler

expedient is to form the channel with two planks joined edgewise as shown in the accompanying figure.



At the upper end of the feed channel on each terrace, a wooden cask may be let into the ground to receive the water coming down from above, and hold a sufficient quantity for various purposes, the necessity of which may arise at any moment.

If the flooding system of irrigation is employed, it is evident that the beds must be lower than the paths, and, indeed, on the same level as the distributing channels. The water is usually admitted into the beds by removing with the hand three or four inches length of the ridge flanking the distributing channel and restoring it as soon as the beds are sufficiently flooded, removing at the same time a temporary dam of wet clay placed across the feed channel to turn the water into the distributors. It would be a great improvement, and one that is easily made, to maintain a permanent opening in the ridge of earth, and to fit to it a movable dam consisting of a piece of wood, flat stone, hard earthenware or sheet iron. Similar dams should be used also in the feed channel. In every other respect the arrangement of beds, paths and channels remains the same as in the side-drenching system.

§§ 8. *Collection and storage of Seed.*

§§§ 1. *Collection.*

Seeds may be obtained either by collecting directly, or through contractors, or by purchase in the market, or by exchange. Owing to the backwardness of forest culture in India, the third source scarcely exists for us, and the fourth is almost as limited. This is, however, no great disadvantage, as seeds collected directly or through contractors must necessarily belong to the latest crop, and are more likely to be fertile and sounder than those obtained otherwise; and not only this, but they can be more thoroughly tested.

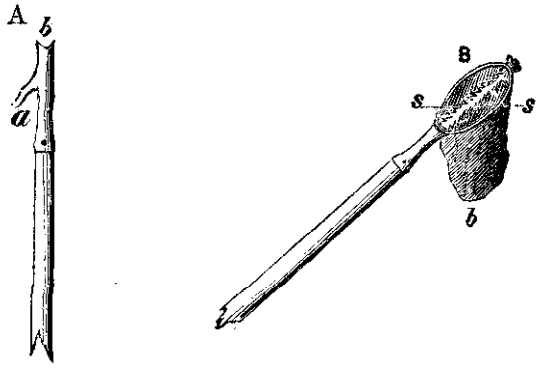
The best seeds are produced by fully fertile, healthy, vigorous trees growing not too close together in a favorable soil and situation. Very young trees usually furnish a large proportion of barren seed, while very old or weakly trees yield seeds which are not only difficult to keep but also produce weak plants. Deformities in trees are often inherited, as for instance twisted fibre, a squat habit, &c. Twisted fibre can be easily detected in trees possessing a cracked bark or rhytidome, as the cracks follow the twist.

Seeds ought to be collected only when they are completely ripe: such as are not fully ripe when taken off the tree do not possess the germinative faculty in the same degree as ripe seeds and, moreover, lose that faculty much sooner. The ripe fruit of some species persist on the trees for a more or less considerable time; *e.g.*, of teak, *Terminalia tomentosa*, *Pterocarpus Marsupium*, sissoo, &c. Such fruit one need be in no hurry to harvest. But there are other species, the majority of the seeds of which, with or without the rest of the fruit, are shed as soon as, or soon after, this ripens; *e.g.*, sal, deodar, *Quercus semecarpifolia* and *dilatata*, *Abies Webbiana*, birch, *Lagerstræmia parviflora*, *Schrebera swietenioides*, &c. The collection of such seeds evidently admits of no delay. Rainy weather ought, whenever possible, to be avoided for the collection of seed, especially of such as are small, *viz.* of *Anogeissus*, birch, *Adina cordifolia*, *Stephegyne parvifolia*, &c.; but this prohibition obviously does not extend to such seeds as are to be sown at once, or, which comes to the same thing, as cannot under any circumstances be preserved, *e.g.* sal, *Quercus semecarpifolia*, &c.

According to the various species, seeds must be collected in different ways. The fruit may (i) be hand-plucked off standing trees, or (ii) off felled trees, or (iii) be gathered off the ground after they have fallen naturally, or lastly (iv) be broken off with a hook from standing trees.

(i). HAND-PLUCKING OFF STANDING TREES.—This method is the most costly of the four, but is the only one applicable in the case of small or light fruit, *e.g.*, *Pterocarpus Marsupium*, *Ougeinia dalbergioides*, *Anogeissus*, khair, sissoo, *Hardwickia*, elms, maples, ash, &c., or of small light seeds that escape from the ripe fruit still hanging on the tree, *e.g.* deodar, silver fir, birch, *Schrebera swietenioides*, *Andromeda*, &c. The seed collector must climb up into the crown of the tree, with or without the help of a ladder, just as he can manage, and with a sack slung over his shoulder. What he cannot reach directly with his hand, he must draw to within arm's length of himself by means of a hook attached to the end of a light but strong sapling or bamboo of sufficient length. Branches and branchlets break off less easily when drawn upwards than if pulled downwards; hence it is always advisable for the collector to climb up to the highest point he can attain and begin by plucking off the fruit hanging at the summit of the tree. The fruit of many species is more or less articulated to the twig which bears them, and is thus easily gathered; but that of some species can only be plucked by twisting or otherwise forcibly breaking off the twig. For the latter class of fruit the use of a cutting implement, such as a pruning knife is to be recommended. Figure A represents a convenient implement,

which combines a hook (a) and a cutting edge forming a re-entering angle (b). Figure B is a rough sketch of the imple-



ment commonly used by mango gatherers, and slightly improved to suit the forester's purpose. The bag (b) receives the fruit or seeds, and prevents them from escaping or falling to the ground; *s s* are fine sharp saw edges. The common Indian sickle may also frequently be employed.

(ii). HAND PLUCKING OFF FELLED TREES.—Trees that are to be cut for export in the ordinary course of work often yield a considerable supply of good seed. They should be felled immediately the fruit is ripe. A pruning hook often facilitates very materially the collection of the fruit. This is the only method applicable to the various kinds of bamboos.

(iii). GATHERING OFF THE GROUND.—The seeds that fall first are generally barren or worm-eaten; they should invariably be rejected. To this end the dead leaves and early fallen fruit or seed should be swept away from under the selected trees. This method of collection is very economical, and is peculiarly suited to large heavy fruit which falls more or less perpendicularly and which does not break up and allow the included seed or seeds to disperse, *e.g. Quercus incana*, the sandalwood tree, &c., sal, *Terminalia Chebula* and *belerica*, &c. To help the fall of the seed or fruit, the branches of the trees may be shaken.

(iv). BREAKING OFF THE FRUIT FORCIBLY FROM STANDING TREES.—When trees marked to fall within a year or so are chosen as the seed-bearers, it may be found inconvenient or impossible to fell the trees as soon as the fruit ripens. On account of the nature and small size of the fruit and seed, the Third Method may also be inapplicable, while the First would be unnecessarily expensive, since there is no reason for sparing the fruit-bearing branchlets and twigs of such trees. The fruit may then be broken off singly or in bunches with the aid of a strong hook forming a sharp angle of about 30° firmly attached to one end of a long sapling or bamboo. The inside

edge of the hook should be sharp and serrated and slightly curved inwards. The hook should be passed over the fruit-bearing branchlet or twig at the point at which it is to be broken off, and jerked downwards; or, if that does not suffice, it should be twisted round once or twice, by which means the branchlet or twig, as the case may be, will be firmly caught in it and a single jerk will then suffice to cut the former through. Where small wood has no value, and there is no objection to thinning out the crowns of the trees, branchlets of a certain thickness may be cut off with a bill hook, and the fruit then hand-plucked from them. Some trees produce bunches of fruit, the common stalk of which dries up at maturity and easily disarticulates from the rest of the branchlet. The panicled fructification of teak is a good instance in point. The present method may be employed with such trees, both independently and also to supplement the Third Method, when all the fruit, although they ripen more or less simultaneously, do not fall together.

§§§ 2. *Treatment after collection.*

The fruit of many trees require to undergo some previous manipulation before the seed is in a fit condition to be sown or stored up. Either (a) the seed is enclosed in a fleshy pulp, *e.g., Dillenia, Schleichera trijuga, Artocarpus, Gmelina arborea, Diospyros,* &c.; or (b) it is covered with a thick tough fibrous rind, *e.g.* cocoanut, &c.; or (c) it is included in a capsule or pod, or between scales, *e.g. Lagerstræmia, Schrebera, Michelia,* khair, *Hardwickia,* babul, *Coniferæ,* &c., or (d) it is surrounded or armed with foliaceous or comaceous appendages, which interfere with its uniform distribution in sowing as well as uselessly increase its bulk and weight, *e.g.* Teak, some *Terminalias, Pterocarpus Marsupium,* elms, maples, pines, firs, poplars, willows, &c.; or (e) it is so full of moisture that it cannot be stored up at once without heating and fermenting, *e.g.* pines and firs, *Anogeissus, Quercus incana,* &c.; or (f), although as ripe as it can ever become on the parent trees, it would germinate badly or after much delay if sown as soon as collected, *e.g.,* teak, *Terminalia tomentosa* and *Arjuna, Pterocarpus Marsupium,* babul, ash, &c.

(a). SEEDS ENCLOSED IN A FLESHY PULP.—In many cases the pulp may be got rid of by allowing it to rot in heaps, and then washing it off in large vats with abundance of water, working the contents of the vats well with strong rods bound together broom-fashion. Edible fruit, such as that of *Zizyphus, Diospyros, Buchanania, Schleichera,* &c., give no trouble; people who live in or close to the forest will bring in all the seed required in return merely for the privilege of collecting the fruit, with occasionally a trifling money renumeration added. Some kinds of fruit may also be given to goats and cattle, which eject the seed when chewing the cud, *e.g. Zizyphus, Terminalia belerica*

and *Chebula, Phyllanthus Emblica, Gmelina arborea, Prosopis spicigera*, &c.

(b). SEEDS COVERED WITH A THICK FIBROUS RIND.—The rind must be torn off with the aid of force and special shears.

(c). SEEDS INCLUDED IN A CAPSULE OR POD, OR BETWEEN SCALES.—The quickest method, when that is practicable, is the application of heat, under the action of which the valves of the capsules or pods and the scales of the cones open out or disarticulate, and allow the enclosed seeds to escape out. In many cases simple exposure to the sun suffices; in others, however, a higher and more sustained temperature is required, and then special drying houses are necessary, in which the fruit to be treated is exposed to the direct action of air heated by steam pipes or over an open fire, and kept at the required temperature with the aid of thermometers. The coverings and scales are separated from the seed by raking or riddling or winnowing, according to circumstances. But the application of heat does not suffice for, or even does not succeed at all, with the fruit of many species, *e.g.* sissoo, *Hardwickia*, babul, khair, &c. In this case, if the seed is tough enough, threshing in sacs or in the open air, or treading with bullocks on a well-beaten ~~level~~ floor in the manner of the Indian agriculturist gives good results. Some of these seeds, however, chiefly of leguminous plants, do not stand such rough treatment, *viz.*, *Hardwickia binata*, sissoo, &c., and the only way to free them, as far as I know, is to manipulate each fruit individually with the hand, in case the separation of the seed from its covering is deemed necessary.

(d). SEEDS WITH FOLIACEOUS OR COMACEOUS APPENDAGES.—The wholesale removal of these appendages, except one by one with the hand, is not always possible without injury to the germinative power of the seeds; but whenever practicable, it should be effected. If the seed is hard or tough, friction, more or less rough, suffices to detach these appendages. When this is the case, a very expeditious method is to nearly, but not quite, fill large stout sacs with the seed, and to thresh these or work them violently backwards and forwards, according to the toughness of the seed, until the appendages are detached or crushed, when they can be easily separated by the ordinary process of winnowing. Treading with cattle may sometimes be found efficacious. Threshing is necessary for seeds of *Terminalia tomentosa* and *Arjuna*, *Pterocarpus Marsupium*, &c. Treading with cattle or friction in sacs will succeed perfectly with teak, &c. With brittle or otherwise delicate seeds the following process may often be employed with the best result:—They should be spread out and sprinkled over lightly with water from a pot with a fine rose, and moistened thus, they should be collected into large heaps. As soon as a gentle heat is felt on inserting the hand into these heaps, they ought to be

spread out to dry. When the seeds are again dry, the appendages will be found to have disarticulated of themselves.

(e). SEEDS TOO MOIST TO BE STORED UP AT ONCE.—The seeds of many species have to be plucked from the parent tree before they are quite dry, in order to prevent their being disseminated and scattered far and wide. Other kinds of seed contain a great deal of moisture even when they fall off naturally. Such seeds should be spread out not more than *from 2 to 3 inches high in a dry, airy, sunny place, and turned* over with a rake twice or thrice daily for a period varying with the kind of seed and the dryness and temperature of the weather. After this they should be piled up higher, the raking being continued as before but being limited to only once a day. This latter process should go on until the seeds are sufficiently dry. Experience alone can tell when this is the case. It is needless to say that in the cold weather the seeds should be removed under shelter while dew is being deposited. As regards seeds that are moist even when they are shed naturally, this drying is really the completion of the ripening process, for such seeds germinate more promptly when they have been thus dried than if sown as soon as they fall off from the parent tree.

(f.) SEEDS THAT REQUIRE A FURTHER PROCESS OF RIPENING AFTER FALLING OFF FROM THE PARENT TREE.—Among agricultural crops our gram is a well-known instance of such seeds: it will germinate freely only several months after it has been harvested. Instances of forest seeds, already given higher up, are those of teak in Central India and Bombay, of *Terminalia tomentosa* and *Arjuna*, of *Pterocarpus Marsupium*, babul, ash, &c. Drying increases the germinative faculty of each one of these species, especially the power of swelling up of the embryo and of the perisperm (when there is one) by the imbibition of water. In the case of teak in Central India, it would appear that continued exposure to all the alternations of the weather during a whole year, provided fermentation is prevented, favours the second ripening process.

(To be continued.)

E. E. FERNANDEZ.